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AUTOMATED CIVIL ENGINEER PLANNING AND EXECUTION SYSTEM (ACEPES)

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Preface

This research furthers the state of knowledge of automation applications for civil engineering air base planning. Although Air Force Civil Engineers (CE) have historically used new technologies to improve their effectiveness, CE combat support has not yet fully benefited from improvements in automation technology. This study provides facts and recommendations necessary to field automation tools that will enable CE to accomplish beddown planning faster, more accurately, and as an integrated player in C4I battlespace management.

The real need for this project was foreseen by Brigadier General Philip G. Stowell, The Civil Engineer, Headquarters Air Mobility Command (HQ AMC). General Stowell continues to push for automation improvements in CE contingency operations. Special thanks are given to General Stowell and his staff for their support and project sanctioning.

Several other organizations, agencies, and corporations have contributed to this research effort. Sincere thanks are given to Colonel Dan Barker (USAF, Retired) of Science Applications International Corporation (SAIC) for his automated C4I system concepts; Mr. Matt Davis of Environmental Systems Research Institute, Inc. (ESRI) for his informative discussions of ESRI's Geographic Information System technology products; and Dr. Jonathon Duke and Mr. Gregg Hill of Wright Laboratory for their insight regarding development of the Planmaster bare base planner product.

We also appreciate the support provided by our research advisor, Maj Chuck Manzione. His assistance in identifying proper research procedures for our study proved very beneficial throughout the process. Finally, we offer thanks to HQ USAF/CEOO engineers for providing us a draft of the AF/CE Automation Strategic Plan; the many engineers and program managers at HQ Air Force Civil Engineer Support Agency at Tyndall AFB, Florida for their technical support; and Capt Carmine Vilardi, HQ Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, for introducing us to their logistics technology product. Without the assistance of all of those noted above, this research project would have been considerably more difficult.

This research was an extremely challenging and rewarding effort. We are confident it will assist the Civil Engineering community to field an automated contingency beddown planning tool.

Abstract

Air Force Civil Engineers have long supported the employment of air power during contingency operations by planning, building, and maintaining platforms to launch and recover aircraft. In the cold war era, these launch platforms were usually collocated operating bases, supported by a robust infrastructure that was well known to CE planners. Unfortunately, drastic changes in our national security environment, and reduced infrastructure overseas, have meant that today's launch platforms are often unfamiliar runways and airstrips scattered throughout the world. CE planners, still tasked to beddown a variety of operational missions, are now faced with a much more difficult challenge. Specifically, they must plan beddowns at more remote locations, with less planning time and less preplanning information.

The objective of this study was to find ways to improve the Civil Engineer contingency planning process through the use of automation technology. This study recommends an automation strategy based on a thorough examination of the air base planning process, existing automation initiatives and products, and future automation technologies. To support this research, the team conducted an extensive literature review and made numerous personal contacts with government agencies and commercial enterprises specializing in automation technology. Our research revealed that despite much effort in this area over the past ten years, a single tool to automate planning,

execution, sustainment, and recovery of air base operations in a contingency environment does not exist but is readily attainable.

This study found there are a variety of government and commercial software products and information databases currently available which can be used to build the foundation of an automated CE beddown planning tool. Commercial off-the-shelf (COTS) software can perform many beddown tasks that include accessing and analyzing digitized satellite imagery, performing engineering design computations, managing data and resources, and providing mapping capabilities. Where COTS software cannot meet specific beddown planning tasks, specific software can be developed to bridge these gaps relatively quickly. Long-term system design should center around robust, shared information databases, interconnectivity with joint C4I architectures, incorporation of new technologies, and conformance with strategic automation guidance.

Chapter 1

Introduction

Imagine receiving orders to prepare for deployment to a remote location within the next twenty-four hours. You have no prior knowledge of the location, and consequently have not had the luxury of conducting peacetime beddown planning for your destination. As a Civil Engineer, your mission is to set up an entire base to support numerous operational and support units who will be arriving at the remote location within days.

This Herculean task encompasses predeployment planning; air base beddown planning and execution; air base sustainment and recovery; and redeployment. The most critical element—air base planning and execution—requires a thorough knowledge of several items such as air base planning factors and principles, user requirements, engineering data, site information, and a host of deployment related information concerning personnel, training, and equipment.

You begin your task by acquiring hard copy maps and data for the proposed deployment location. Researching this data takes time, and your search often results in finding only outdated or incomplete information. You next consult voluminous amounts of regulations, Air Force Instructions, and computer databases to help you determine your beddown requirements.

Having successfully run this gauntlet, you can link your requirements to the existing site conditions and begin to get a clearer picture of critical beddown details. Whether you're a Major Command (MAJCOM) planner preparing a decision package for staffing and approval, or a base-level planner preparing to brief the wing commander and then deploy, developing a functional and effective air base layout is a time-consuming, manually intensive exercise that produces inflexible results which are not easily modified if assumptions or conditions change.

The civil engineer in the above hypothetical scenario needs a new set of tools to accomplish contingency planning tasks in the 21st century. While many tools do exist, they are not integrated to maximize their effectiveness. Advances in technology and a changing global political environment require that the U.S. respond quickly to a variety of military challenges. These same advances in technology, especially in automation software, hardware, and communications, can be used to improve the contingency planning process.

This research project examines the contingency air base planning process; provides a practical guide of existing technologies; and presents specific short and long-term recommendations for the project sponsor, Headquarters Air Mobility Command. For the purposes of this research project, the term Automated Civil Engineer Planning and Execution System (ACEPES) refers to the collective set of recommendations made in this report. Our hope is that these recommendations will lead to a fielded product useful to Civil Engineers tasked with contingency beddowns.

Air Power and Civil Engineers

Since World War II, the American military has relied heavily upon air and space power. Air Force (AF) aerospace doctrine, outlined in Air Force Manual (AFM) 1-1, recognizes that air and space power results from the effective integration of platforms, people, weapons, bases, logistics, and all supporting infrastructure.[1] No one element is more important than another as each element is essential and interdependent. Air Force Civil Engineers, responsible for providing, operating, maintaining, sustaining, and recovering air bases, is one such essential element. CE ensures the availability and operability of the air bases that enable commanders to employ air and space power. The function of CE is most critical in contingency operations when new air bases, within reach of the conflict, must be planned and executed.

Throughout history, CE contributions in support of air power have been numerous and include heavy airfield construction and repair, rapid runway repair, bomb damage repair, arresting barrier and airfield lighting installation, fire protection, explosive ordnance disposal, and disaster preparedness. In the Gulf War for example, CE planned and executed the development of over 30 different airfields throughout the region. These airfields were required to support over 55,000 military personnel and more than 1,500 aircraft. CE erected over 5,000 tents, built more than 300,000 square feet of buildings, and laid enough asphalt to cover 120 football fields.[2] At one air base in Saudi Arabia, CE constructed over seven linear miles of aircraft revetments. These revetments proved invaluable when they prevented damage and loss of life during an inadvertent missile firing from a parked A-10 aircraft.[3] Civil Engineers have proven to be force multipliers in the employment of air power.

The New National Security Environment

The Civil Engineer air base planning process, like the Air Force itself, has had to adapt to a changing global environment. Rather than focusing on a Cold War European scenario, the AF must now respond to global uncertainty and regional instability. The USAF strategy of "global reach, global power" must be supported with a force that is dynamic, high-speed, precise, and mobile. Regional conflicts, today and in the future, will occur in remote places around the world. These conflicts have the potential to involve the full spectrum of force projection from peacekeeping to military operations other than war (MOOTW). For example, in 1994, the AF flew over 8,000 sorties for humanitarian and disaster relief and over 230,000 sorties over Bosnia and Iraq since the Gulf War.[4] Future contingency deployments worldwide will continue to involve unconventional missions for the military such as nation building, humanitarian assistance, and natural disaster recovery.

To support such a global presence, the AF must be capable of deploying to and operating from air bases that are provided to us, regardless of existing infrastructure. The closure of many U.S. main operating bases overseas and reluctance of foreign nations to permit permanent military bases on their soil have limited basing options for U.S. forces during contingency operations. These same nations preventing permanent bases on their soil are themselves subject to internal and external aggressions that usually result in some form of U.S. assistance. As a general rule, runways, taxiways, and air terminal facilities in countries around the world can be offered to U.S. forces in support of air operations. These bare base locations, often inadequate, must be transformed by Civil Engineers into legitimate power projection platforms for combat operations in support of any mission.

So strong and important are changes in current contingency operations that Air Force Civil Engineer doctrine was modified in 1994 to emphasize these challenges.[5] Smart and efficient planning of contingency air base development is vital, considering the continual declines in funding and manpower expected within the Department of Defense (DOD), the AF, and CE.

The Fourth Dimension

The changing landscape of the national security environment has forced today's military to exploit force multipliers. No longer can the military rely solely on technology designed for land, sea, and air frontiers. Space, as the fourth dimension, represents a medium of limitless potential. The Gulf conflict has often been described as the first "space war" referring to the key contribution of satellites for command and control, communications, early warning, surveillance, intelligence, navigation, targeting, damage assessment, and news reporting.[6] Combat information, often generated through space-based assets, now rivals weapons as the commodity most vital to success in war. Accurate, precise, and timely information lies at the heart of military endeavor on the battlefield.

The Civil Engineer air base planning process has not fully captured the benefits of this new "Information Age." For example, despite the advanced technology available to Gulf War operational planners, the initial airfield selection accomplished by CE planners was based on reference information that was often over five years old. Basing packages were put together with limited airfield data and few, if any, formal site surveys. Lessons-learned accounts from Civil Engineers deployed in the Gulf frequently detailed base

expansion problems attributable to poor initial air base planning efforts. The benefits of satellite technology, including multi-spectral imagery and Global Positioning System (GPS) applications, are key ingredients to a state-of-the-art air base planning tool.

The Need for Automation

The contingency air base planning process has been, and continues to be, a laborious and resource intensive activity. Engineers acquire as much information as possible—base maps, aerial photographs, as-built drawings, site surveys, volumes of planning factors, engineer references, host-nation support agreements, base support plans, and intelligence data. Much of the data is incomplete, outdated, and in various hard-copy and computer database formats. The ensuing process is a cumbersome analysis that yields a relatively inflexible air base development plan. Furthermore, it results in a product that does not automatically integrate with intelligence, logistical support, and command and control elements—key functional areas involved in theater battle management (TBM) and Command, Control, Communications, Computers, and Intelligence (C4I) systems.

Compounding the lack of information, the planning process itself is cumbersome and yields a relatively inflexible air base development plan. Consider for example one aspect of beddown planning—aircraft parking. Engineers must first determine how many aircraft (and of what type) will be deployed to the new location. Given aircraft type, the engineer researches wheel loading and pavement condition information to determine general parking areas. Next, information is obtained with respect to anticipated munitions, aircraft clearances and maneuvering space, taxi lane width, parking orientation requirements, exhaust blast zones and other physical and operational constraints. A

scaled map of the deployment location airfield is obtained, allowing the engineer to manually calculate the maximum parking capacity of the ramp space, parking configurations, and specific parking spots. If the operational planners change mission planning factors (aircraft numbers and type, munitions requirements, and deployment locations), the engineer must reaccomplish planning from the start.

Furthermore, the need to automate is solidified by the realization that the current CE planning process yields a manual product that does not integrate well with automated TBM and C4I systems now being developed by intelligence, logistical support, and command and control functional areas. If CE wants to be responsive to commanders in future contingencies, automation is mandatory.

Why then has the CE community not realized the full potential of automating the air base planning process? That fundamental question was the genesis of this research effort. From this fundamental question, we concluded the first step necessary to enable some or all of the air base planning process to be automated was an evaluation of currently available software, hardware, and database tools. Like our HQ AMC/CE sponsor, and HQ USAF/CE, it is our strong conviction that automation of the CE contingency air base planning process will provide engineers with a better analytical decision tool and improve interoperability between critical battlefield management systems at field, staff, and joint levels.[7] From this justification of the need for automation, we derived our basic research objective: *How can Civil Engineers use automation to improve contingency planning and execution processes?*

The Air Force Civil Engineer, HQ USAF/CE, in the *Automation Strategic Plan*, recognizes that CE automation efforts are widely applicable to the global environment

and that civil engineering, like logistics, contracting, medical, personnel, and security police; must use, provide and share real-time, standardized information.[8] The days of proprietary information and stovepipes must change—future information software must comply with DOD open architecture standards and be integrated into a single logical database for use by AF organizations at all levels, DOD, and the federal government. Consequently, AF/CE has established the Automation Steering Group (ASG) to provide a useful roadmap that outlines the vision, goals, and strategies for software, hardware, and communications infrastructure that will become the next generation of CE automation systems.

Scope and Limitations

This research effort describes recommended automated planning tools for the Civil Engineer, and provides a systematic review of representative existing technologies and developmental efforts. It also recommends various approaches to implement improved air base planning methods by describing specific system characteristics, interfaces and functional relationships of an automated planning tool. Recommendations are provided for two different implementation schemes: immediate to short term (present to three years) and long term (three to ten years).

Because air base planning involves art as well as science, there is no perfect tool. This research will however, improve the analytical and decision tools available to Civil Engineers so they may be more responsive to both their commanders and the forces they support. The technology to begin automating the CE air base planning process exists today and should be fully exploited. The recommendations provided herein are based on

specific requirements associated with air base planning and will assist HQ AMC and other commands by providing specifics on hardware, software, databases, and automation technologies. Follow-on studies of the recommendations made in this research effort are encouraged as they will take advantage of the continuing progress in technology development expected in the coming months and years.

Remaining Chapters

The following chapters lay the course for transforming the current air base beddown planning process into the ACEPES vision. Chapter 2 discusses CE planning and execution processes; DOD and Air Force automation frameworks within which CE must integrate; and the literature review conducted as part of this research. Chapter 3 documents the methodology used in this research project to support our analysis and recommendations. Chapter 4 presents our research findings and identifies existing technologies that are available (or soon to be available) to CE contingency planners. Chapter 5 analyzes these technologies against the requirements of the contingency planning tasks CE must accomplish. Finally, Chapter 6 presents our recommendations for the short- and long-term implementation of ACEPES, recommendations for future research, and our final conclusions.

Notes

[1] AFM 1-1 *Basic Aerospace Doctrine of the United States Air Force,* vol. 2, March 1992, 199–208.

[2] AFDD 42, *Civil Engineer*, 28 December 1994, 12.

[3] Ronald B. Hartzer, *Air Base Engineer and Services Support Report,* 7 December 1995, 1–17.

Notes

[4] Col Tome Walters, "Toward Tomorrow's Air Force," briefing, Senior Leader Orientation Course, HQ USAF, Washington D.C., 5 May 1995.

[5] Ronald B. Hartzer, "Civil Engineers Implement Revised Doctrine," *The Civil Engineer,* Summer 95, 12.

[6] Alan D. Campen, *The First Information War* (Virginia: AFCEA International Press, 1992), 121–133.

[7] Civil Engineer Automation Steering Group, *Air Force Civil Engineer Automation Strategic Plan*, 20 September 1995, 1–30.

[8] Ibid.

Chapter 2

Background and Literature Review

Introduction

This chapter provides the reader with a broad knowledge base on three issues that are key to understanding the research. First, this chapter examines the CE planning and execution processes that are proposed to be automated. Since the focus of this research effort is the recommended development of an automated planning tool, an exhaustive, in-depth review of CE processes is not appropriate. However, a general understanding of what CE does to maintain ready forces, plan contingency beddowns, construct and sustain expedient bases, recover base facilities and assets after disaster/attack, and redeploy assets following mission completion is beneficial.

Second, this chapter explores the existing DOD and Air Force automation framework within which the proposed system must operate. As stated earlier, the days of isolated, "stovepipe" functional computer systems are numbered. Past USAF automation efforts were developed as separate systems by functional communities. Each functional area, for example base supply, personnel, and aircraft maintenance, typically developed stand-alone, mainframe systems for their mission requirements. Given the state of technology at the time, isolated computer systems provided a practical automation approach by

naturally dividing Air Force activities into manageable segments. However, because those segmented, functional systems have little or no interconnectivity, they provide limited opportunity for information exchange and do not take full advantage of today's technology. Future systems, such as ACEPES, must comply with open architecture and communication standards in order to be integrated into the next generation DOD and federal agency automation network currently under development.

Finally, this chapter provides a review of two typical automation systems found during our literature review that demonstrate the potential success of the system we propose. These example systems are offered as proof that automating the CE beddown planning and execution process is conceptually valid, and to provide the reader an appreciation for the current state of automation research within similar areas.

Civil Engineers and the Planning and Execution Process

Civil Engineer Organization

The Civil Engineer mission is to provide, operate, maintain, restore, and protect the installations, infrastructure, facilities, housing, and environment necessary to support air and space forces having global reach and power, across the range of military operations[1]. As such, Air Force Civil Engineers are organized into two basic types of squadron units: Base Civil Engineers (BCE) and Rapid Expeditionary Deployable Heavy Operational Repair Squadron Engineers (RED HORSE).

BCE units exist at every Air Force installation and are charged with base development, facility and infrastructure operation and maintenance, fire protection, crash rescue, environmental management, housing, disaster preparedness, explosive ordnance

disposal (EOD), and technical engineer services. During contingencies, these same units are tasked and deployed to provide the same functions at forward operating bases. Deployed BCE units are referred to as Prime BEEF (Base Engineer Emergency Force) teams.

RED HORSE units are not tied to specific bases and are specially structured to provide rapidly-deployable "heavy engineer" capabilities. During peacetime, they accomplish construction and major repairs worldwide at U.S. bases. In contingencies and periods of conflict, RED HORSE is mainly used for major bare base development, heavy damage repair, and large force beddown tasks. They are not responsible for operation and maintenance of the forward operating base (this is a role of Prime BEEF). Recent fiscal realities have driven the Air Force to reduce the number of active RED HORSE units from four to two.

Civil Engineer Planning and Execution Process

Regardless of the contingency situation or the type of engineer team that deploys, the process of preparing, planning, executing, and sustaining a force beddown is somewhat generic. It can be divided into four major sub-processes: predeployment, force beddown, sustainment, and redeployment. These four sub-processes can be further delineated into specific tasks as shown in Table 2-1. These tasks, and the data associated with each, will determine the feasibility of using automation to improve the overall beddown planning and execution process. An explanation of these follows.

Predeployment. Like all military organizations, CE must ensure proper training, exercising, equipping, and planning to guarantee their readiness and ability to perform the tasks required of them should the U.S. project military force. Personnel training not only

includes mobility requirements such as chemical/biological and weapons qualifications but specialty training such as basic carpentry and operation of heavy equipment. Personnel qualification and competency, as well as the status of deployable unit equipment and supplies, are reported through the Status of Resources and Training System (SORTS) monthly report.

Training is further enhanced through wing exercises and Operational Readiness Inspections. These provide the opportunities to exhibit learned skills and test the squadron's capabilities to operate in bare base environments while supporting the Wing's mission and personnel. These exercises allow CE an opportunity to plan, construct, and operate an expedient base under exercise conditions as close to actual deployment as can be simulated, and provide an excellent measure of the unit's readiness which cannot be attained through the administrative SORTS report.

Table 2-1. Force Beddown Processes

SUB-PROCESS	TASK
Pre-Ddeploy-ment	**Exercises** **Training** **SORTS (Personnel, Equipment, Materials)** **OPLANS, CONPLANS, Functional Plans**
Force Beddown	**Beddown Planning** **—Mission Analysis** (force structure, ops level, threat, projected base population) **—Host Nation Analysis** (support/restrictions, climate, terrain, infrastructure, rainfall) **—Site Analysis and Selection** (existing facilities, ramp space, utilities, airfield conditions, arresting barriers, airfield lighting, NAVAIDs, topography, vegetation, soil types, theater areas of interest, airspace characteristics) **—Site Requirements** (calculation of needed utilities, tents, latrines, airfield systems) **—Site Layout** (aircraft parking, utilities, tents, mission support, security, clear zones, noise, air base defense, wind, topography, expansion) **Execution** **—Time-phased deployment of assets** **—Time-phased construction of base** (prioritized tasks, construction schedules, resupply schedules, costs) **—Resource management and security** (personnel, equipment, materials, vehicles, facilities, infrastructure) **—Environmental management**
Sustain-ment	**Combat Support Operations** —Operations and Maintenance of facilities and infrastructure —Resource Management and Security —Robust Supply Operations —Disaster Preparedness/Air Base Operability Planning —Explosive Ordnance Disposal —Firefighting and Rescue Operations —Environmental Management —Camp Support & Administration **Recovery Operations—includes all of the above plus:** —Damage Assessment —Minimum Operating Surface Selection/Rapid Runway Repair —Expedient Repair of facilities and utilities
Redeploy-ment	**Reconstitution of assets** (disassembly, cleaning, packing) **Time-phased redeployment of assets** (customs, TPFDD) **Resource management and security** **Environmental Management**

In today's environment of uncertain international crises and increasing roles for the U.S. military, CE units are realizing more than ever that a rapidly-deployable engineer capability is necessary to provide forward bases for aerospace force projection and application.

Force Beddown. Prior to deployment, a comprehensive plan must be developed to ensure minimal fog and friction impact the engineers' job of constructing a fully-operational base. Although some situations (like the major build-up for Desert Shield/Storm) will drive force deployment planning to the Air Force and/or Joint Staff level, the tasked MAJCOM will always be a key player. In today's environment of Military Operations Other Than War (MOOTW) and limited objectives, individual MAJCOMs are routinely tasked to plan and deploy engineer functions for given locations and missions.

As stated in AFM 1-1, "Aerospace forces depend on surface bases, require large amounts of consumable stores (food, water, fuel, munitions), and particularly depend on highly technical maintenance, including spares. In addition, airmen require at least rudimentary human services if they are to function effectively."[1] Thus, in many cases, a small base must be constructed very quickly to provide this foundation for air power, and as such the planning process is very intense. Beddown planning begins by gathering as much information as possible from any available source to define the basic mission requirements. As was seen earlier in Table 2-1, Air Force beddown planning focuses on data very similar to the U.S. Army's METT-T criteria (mission, enemy, terrain and weather, troops, time available).[3]

Mission analysis provides the basis for the operation, but requires answers to a whole series of questions such as: What are the objectives? What types and numbers of aircraft

will operate from the planned location (both fixed wing and rotary)? Will transient aircraft such as resupply and medical evacuation be involved? What type of munitions capability will be required? How long will planned operations last? Will the base's mission stay static or are additive/different missions planned at some point(s) in the future?

Furthermore, information on the enemy must be included to fully appreciate mission objectives, desired capabilities, and air base security requirements. Types of attacks that can be expected (air, terrorist, saboteur, etc.) and in what intensities must be analyzed for the planned location. Additionally, probable enemy weapons (chemical, biological, missiles, car bombs) and the projected threat level during base construction and operation must be assessed and incorporated in the plan.

An analysis of host nation characteristics is also necessary to determine a variety of information including: what type of government exists, special conditions imposed upon us by the host government, and available host-nation support (both industrial/commercial base and labor). Background information on indigenous religions, customs, and culture will also smooth the transition and minimize tensions as U.S. forces begin operations in country.

All possible airfields are then analyzed within the area of operations using the above information, maps (if available), published airfield data, host nation information, and other available intelligence. Knowledge of existing facilities and infrastructure, topography and weather at these locations is also desired. Obviously, operations in a desert demand significantly different basing criteria than those in a jungle or arctic region. Not

only will facility design criteria be different, but human necessities such as water and heat/air conditioning will vary.

Finally, the number and types of troops to be deployed as well as the operational time schedule must be discerned. The number of troops stationed and transiting the planned base will directly define the magnitude, types, and construction schedules for needed facilities and utilities. Will it be joint forces, combined forces, or just Air Force? Will the base be a staging area for joint forces arriving in country and then forward deploying to other locations? When will forces hit the ground? What is the phasing for force deployment?

Understanding as much of the above information as possible, the MAJCOM engineer planners begin an inflexible, manual process to compute basing requirements. First and foremost, an operational analysis must be performed in close coordination with the operational planners. Is the airfield big enough to support the projected force structure? Will the airfield pavements hold-up to the projected air traffic? Are there navigational aids (NAVAIDs) and airfield lighting systems that must be installed or maintained? How does this site compare with alternative sites in the theater as far as operational capabilities?

With operational limitations understood, a mechanical process begins with the determination of required facilities and infrastructure. This exercise is driven by the levels of training and personal experience possessed by the planner as well as planning factors and construction standards, most of which are found in Air Force Pamphlet (AFPAM) 10-219. This pamphlet is based on JCS-defined planning criteria and is the Air Force beddown planner's "bible."

For instance, knowing the projected base population, the climatology for the deployed location, and any special mission requirements results in planning factors that are applied to derive daily water requirements. The planner then sizes a water purification system along with distribution, storage and disposal methods. Of course, to have an effective water purification system, you need a raw water source to purify; here again, reliable intelligence on the location is important. If such a water source is available in sufficient capacity, the planner finalizes the system; if not, alternate locations will be analyzed or plans will be made to use bottled or trucked water. Similar computations are made to determine the types and quantities of operational facilities, support facilities, and remaining infrastructure.

Each type of facility (e.g., billeting, maintenance, munitions storage, latrines) required for the base is manually computed along with its associated support systems (electric, air conditioning/heat, water) using the planning factors from AFPAM 10-219 and independent variables such as base population and numbers of aircraft. Once all of the facility and infrastructure requirements are computed, they are compared with existing facilities and infrastructure available for use (hangars, hard-walled facilities, utility systems). Existing assets are utilized where possible to minimize logistics support required for build up.

The planning process does not end with the determination of existing assets and additional requirements (sourced and constructed). With whatever intelligence is available, CE planners lay out the entire base on paper. At this point in the planning process, the actual engineer unit tasked to deploy assumes the majority of the remaining planning responsibilities. Coordinating and working with their MAJCOM and the

deployed commander, if available, the base site plan is developed by applying ten principles[4] to maximize base efficiency and sustainability (shown below in Table 2-2). These ten principles often overlap and at times conflict increasing the desirability for an automated decision process.

Thus, many factors play in base development, and continual changes to mission requirements and base layout will occur which may or may not effect previously planned portions of the base. It is up to the engineer to manage all the changes, provide proper guidance, and execute the plan—often in a very compressed time schedule. Today, this entire process is manual with the exception of Computer Aided Design and Drafting (CADD) capabilities which allow planners to map out the base prior to deployment if general characteristics of the location are known. If accurate intelligence is not available to alert the engineer to the specific conditions of the location, assumptions must be made.

Once on the ground, actual conditions will always drive changes to a planned base layout. Although RED HORSE units deploy with CADD capabilities, Prime BEEF engineers rarely have such resources and rely heavily on manual techniques.

Table 2-2. Planning Principles

PRINCIPLE	CONSIDERATIONS
Redundancy	Provide alternate and back-up facilities and utilities for critical operations
Resiliency	Design facilities and utilities for expedient repair capability; plan facilities for multiple functions
Reliability and Maintainability	Back-up utilities (i.e., second water purification unit); maintain large spare part inventory and provide for resupply
Interoperability	Standardize systems to allow for interchangability of parts
Accessibility	Site facilities for efficient operations (i.e., aircraft maintenance by the ramp and dining facilities within billeting area)
Sustainability	Ensure mission capable throughout duration of campaign (i.e., sufficient ramp space for larger resupply aircraft)
Warning, Assessment, and Control	Provide real-time combat information and situation assessment capability (i.e., public address system)
Plan for People	Plan for personnel comfort and convenience (i.e., shelters w/ adequate ventilation, latrines close but downwind)
Protection of Resources	Provide aircraft revetments; aircrew shelters; hardened facilities; camouflage, concealment, and deception
Combat Siting	Use natural terrain and positioned obstacles for increased base security and defense

The planning process described above is very intense and often complicated. The value of automation cannot be denied: performing mechanical computations, providing access to real-time intelligence, connecting decision processes with critical planning considerations, allowing efficient management of deployed resources. In true crisis situations, engineers will be deployed without adequate time to accomplish in-depth base planning. Even in these situations, engineers can exploit automation by initiating the planning process on the flight into the deployment location.

Once a site is planned, the assets needed to construct the base must be transported and marshaled in country. These assets are many to include heavy equipment like front-end loaders, forklifts, dump trucks, bulldozers, and airfield sweepers; hand tools and hardware supplies; utility and distribution systems; POL storage systems; aircraft revetments; and the necessary tents, lights, and generators to erect a camp. The logistics effort is substantial and in situations like Haiti or Desert Shield, the majority of logistical support was shipped rather than airlifted.

Thus, time-phasing the deployment and delivery of construction assets is crucial to a planned deployment as is the proper time-phased construction effort. With mission-essential tasks being the first priority of any beddown, competing demands on CE team are chaotic as everyone floods the system for operational facilities, billeting, showers, hot food facilities, utilities, and support facilities. Work must be prioritized and status reports given to the base populace to ensure customers are informed and knowledgeable about schedules and engineer capabilities.

The materials and equipment involved in such a construction effort represent a substantial commitment of U.S. tax dollars and must be protected and managed appropriately. Full accountability of these resources is necessary both to ensure efficient construction and maintenance of the base as well as to guarantee the ability to reconstitute and redeploy these assets at the end of the operation.

In addition to the normal CE efforts involved in readying an airfield for operations, today's concern for the environment has added another set of concerns in the engineer's work schedule. Even during war, precautions to limit environmental impacts must be taken and include berming POL storage areas to limit spill damage; developing spill plans

and procedures; siting, storing, and disposing hazardous materials properly; and conducting wastewater treatment and solid waste disposal properly to name just a few.

As can be seen, there are many competing and overlapping factors that must be taken into account during the construction of a base. Manual log books and ledgers are today's management tools, but the reader can see that automation of such processes would be of great benefit to the engineer and the Air Force effort. Requirements competing for limited CE resources and available land could be managed through an automated (weight-valued if necessary) priority system that could be easily manipulated to test alternative schedules and maximize construction efforts.

Sustainment. The engineer's job does not end with the completion of construction. Today's engineers deployed in support of contingencies provide basic operation and maintenance of base facility and infrastructure systems, disaster preparedness expertise, explosive ordnance disposal, fire fighting and rescue operations, and base recovery operations following an attack or disaster.

Predominantly, these functions are directed and managed through manual processes: inflexible hard-copy base maps, log books, wall charts, manual calculation and plotting, and in-person status reports. These methods work, but do not provide much flexibility, speed, or efficiency. Not only is it inefficient to continually update base maps manually, but much of the information documented in one log book or map must be manually transferred to briefing charts, status boards, and reports. Furthermore, there is often insufficient time to manually calculate, map, and analyze alternative solutions to a problem. Personal experience and training of the individuals on-the-ground play key roles in ensuring that educated decisions are made without the benefit of much analysis.

Redeployment. As the mission winds down and the feeling of accomplishment pervades the camp, the CE's job continues. While forces are redeployed home, disaasembly of the camp must be managed and executed in an orderly and structured way. Tents and other assets must be disassembled, cleaned, inventoried, palletized, and checked through customs, not to mention entered into the Time-Phased Force Deployment Data (TPFDD) to ensure transportation. Camp tear-down, much as camp construction, must be phased in accordance with camp population changes; as troops redeploy, not only do their billeting tents come down, but utility systems and support facilities are downsized to meet the lower demand of the smaller camp. Also during camp reconstitution, environmental issues must be addressed to ensure that U.S. forces leave the area "clean" and to the satisfaction of the host nation. Thus, resource management, security, and scheduling capabilities are essential, as they were during camp build-up.

Automation Framework

Automation of the air base planning process is not simply an exercise in applying modern technology to a manual procedure. Given the Chairman of the Joint Chiefs initiative to develop C4I infrastructure providing seamless connectivity of information for the joint warrior, automation of the force beddown process will enable CE to become an integral part of command and control modernization. This is important for all threat spectrums from mobilization through attack and is especially useful for CE air base recovery activities that return a base to operable status.

Existing CE base recovery information management (battle damage assessment, minimum operating strip selection, chemical/biological plotting, air base status) can be greatly improved in terms of survivability, speed, and integration through automation and improved communications connectivity. Real-time, shared information between Survival Recovery Centers and Damage Control Centers is necessary and achievable. AF Civil Engineers are intimately familiar with the future C4I environments they will operate in and are working the associated hardware, software, and communications infrastructure requirements. The primary DOD and AF C4I systems are briefly discussed below.

C4I Environment

Global Command and Communication System (GCCS). GCCS is a single C4I system which will replace DOD's Worldwide Military Command and Control System. GCCS will provide a virtual command center that can be accessed globally. Network access to GCCS will give warfighters more immediate access to data and allow them to tailor data inquiries to specific mission requirements. Initially, GCCS will provide support at the command post level but will eventually reach the warrior on the ground and in the cockpit. Military personnel will be able to gain visibility into the system through a widely distributed user-driven network. Access to GCCS will be through a classified military channel of the Internet known as the Secret Protocol Router Network (SIPRNet). Much of the information required for CE planning, such as mapping and airfield data, will be obtained through GCCS.[2]

Wing Command and Control System (WCCS). WCCS will provide the baseline architecture required at the Air Force wing-level for a mobile C4I capability to support crises and contingency operations. WCCS will provide wing commanders and their staffs

a garrisoned and deployable automated C2 capability that will provide an integrated, composite picture of wing/unit resources and will monitor wing operations during war, contingencies, exercises and training.[3] WCCS will "enhance sortie generation, force employment and mission reporting" by consolidating "operations, intelligence, weather, resources, and combat support information into a single system for mission scheduling and planning."[4]

Looking upward within the overarching C4I system architecture, WCCS is intended to be compliant with the GCCS architecture and common operating environment, such that information from WCCS can be passed through the Joint Forces Commander and Joint Forces Air Component Commander to other Air Force wings as required.[5] Similarly, looking downward in the system architecture, WCCS is intended to accomplish many of its functions, for example provide near real-time status on local air base operations, medical facility information, personnel, and security, by interfacing with other systems within each of the functional areas noted.[6]

WCCS will provide the wing commander a substantial amount of information associated with CE issues. The information WCCS will receive from CE includes Minimum Operating Strip (MOS) headings, dimensions, restrictions and limitations; nuclear, biological, and chemical threat; runway/taxiway repair completion times for sortie generation; unexploded ordnance locations; status of recovery forces and repair actions; status of critical equipment, utilities and facilities; and status of firefighting equipment.[7] As envisioned in this research, ACEPES will be the source of this information for WCCS.

The fundamental computer resources associated with WCCS are intended to make use of an "evolutionary acquisition strategy, rapid prototyping, extensive user involvement, and integration of commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) components and existing software packages."[8] WCCS will be the "core of the Unit-Level Theater Battle Management architecture and will connect to other joint and multinational systems."[9]

Future Wing Level Environment. All new USAF automation applications will have a common focus—a "single logical database" where real-time information is shared with the entire wing and higher headquarters. Headquarters, Standard Systems Group is the AF focal point for integrating all functional information systems through the vision of the Global Combat Support System (GCSS)[10]. Integration through GCSS environment will provide an open database architecture that allows many functional applications to use the same information.[11] For example, a person's deployment status would be in a single database location, thus eliminating potential data discrepancies between the person's unit, the Military Personnel Flight and the Logistics Planning Center. A graphical depiction of this concept is presented in Figure 2-1.[12]

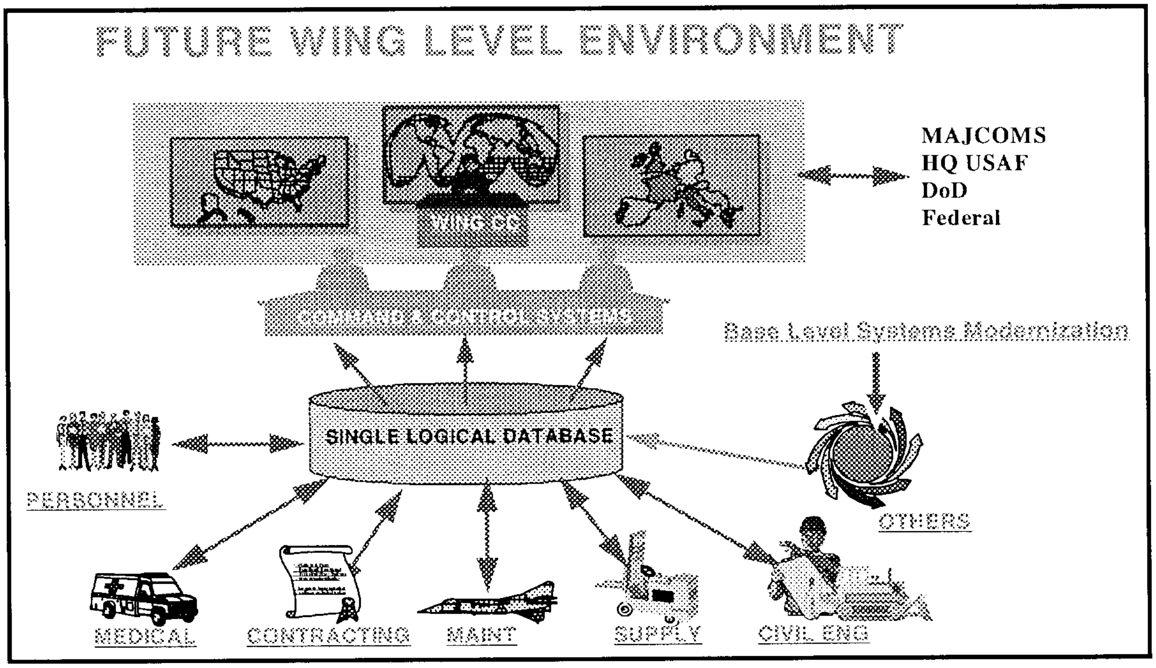

Figure 2-1. Future Wing Level Database Environment

Among the many data links of the future, key interfaces with ACEPES must include the upcoming GCCS environment and its components such as WCCS, the Deliberate and Crisis Action Planning and Execution System (DCAPES)[12], and the logistics planning system, Enhanced Contingency Logistics Planning and Support Environment (ECLiPSE). Those systems will be the primary conduits for wing operational and deployment planning, leading to CE inputs needed for wing beddown planning and building the wing's TPFDD. Whatever system is developed for the Civil Engineer beddown planning and execution process, it must be capable of working within the full range of developing C4I infrastructure.

AF/CE is committed to standardized and appropriately-integrated automation to maintain USAF uniformity, while maintaining MAJCOM and base flexibility. The AF/CE Automation Strategic Plan (ASP) sets forth a vision for automating CE activities, not just for the sake of automation, but to accomplish the mission with excellence in both

peacetime and contingencies. The vision of the ASP is for CE to use "real-time, shared information databases to share standardized data with Wing, MAJCOM, HQ USAF, DOD, federal, and other organizations to maximize operational and contingency support."[13]

Automated Engineering Systems

The literature review revealed that there are numerous existing automated systems designed to perform tasks similar to those performed by USAF Civil Engineers. In the interest of brevity, only two of these systems will be presented. The first, the U.S. Army's Theater Construction Management System (TCMS), is representative of several formally structured and designed applications found in the literature. These types of systems, tailored for specific tasks, demonstrate that technology can be applied to planning and execution tasks by using COTS software and custom programming.

The second system presented below, identified as packaged systems, is a conglomeration of off-the-shelf software programs packaged together and applied to maximize the strengths of individual automation tools to accomplish specific tasks. This system is representative of the successes that were noted in the literature of applying technology to automate processes without having to resort to custom programming. Both of the systems presented, and those found in the literature, highlight the strength of applying today's technology to the research objective.

Theater Construction Management System

Automation of engineering functions, both peacetime and wartime, is not a new concept nor is it one practiced solely by the Air Force. The U.S. Army Corps of

Engineers saw automation as a way to decrease the planning and design time required of their heavy engineer battalions and developed Theater Construction Management System (TCMS) in 1994. Before TCMS was developed, Army engineers accomplished planning, logistics, design and construction tasks independently without the benefit of past experience or standard designs.

Recognizing that existing databases of engineering technical manuals, standardized designs, bills of material, and construction cost estimates could be tapped through automation, the Construction Engineering Research Laboratory (CERL) developed TCMS. CERL made maximum use of COTS software including Microsoft Projects Version 4.0 and AutoCAD. CERL complemented the COTS software with specific government-developed software to bridge COTS deficiencies in accessing databases. TCMS development and implementation has yielded substantial improvements for Army engineers including reduced costs, expedited construction planning and design, and enhanced sharing of lessons learned. The successes of TCMS encouraged the Army to expand its use beyond standard construction projects and into the arena of nation-assistance programs involving the construction of community projects such as schools, roads, bridges, wells, and dispensaries.[14]

Packaged Systems

While TCMS is a good example of successfully merging COTS and government-developed software, the literature identified several instances where COTS software alone was sufficient. For example, the feasibility of using a conglomeration of COTS software to aide in the contingency planning process was proven with dramatic results during the U.S. Proximity Talks held in Dayton, Ohio in November 1995. These talks, aimed at

restoring peace to Bosnia-Herzegovina, were greatly assisted by engineers from the U.S. Army Topographic Engineering Center (TEC). The commander and deputy director of TEC, Colonel Rich Johnson, related how they used computer work stations loaded with a variety of software, terrain data, and geographic information from the Defense Mapping Agency and various intelligence agencies to take the negotiators on a "virtual electronic flying carpet . . . into areas of interest where they could roam at will via a joystick." Colonel Johnson goes on to note how their automated systems also allowed them to "create perspective views of the terrain by draping aerial photographs or a picture of a map over a matrix of digital terrain elevation data to visually assess how mountain goat trails could be turned into all-weather roads," through computer technology. Colonel Johnson concluded by noting that "such virtual reality, fly-through systems are general purpose tools that can support tasks ranging from rehearsals of bombing missions to plans for new infrastructure in war-torn nations."[15]

Summary

This chapter provided an overview of the literature search findings relative to three key areas. The first area was a review of the CE contingency beddown planning and execution process. The second area was the overarching C4I architecture within which ACEPES will be required to operate. Finally, this chapter presented two representative systems found within the literature to validate the concept that automation is a viable solution to the research problem. The next chapter will describe the methodology applied during the research.

Notes

[1] AFDD 42, *Civil EngineerDoctrine*, 28 December 1994, 4.

[2] AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*, vol. 1, March 1992, 15.

[3] FM 100-5, *United States Army Operations*; 14 June 1993, 60–62.

[4] AFPAM 10-219, *Contingency Response Procedures*, Vol 5, 1 February 1995, 2–4 through 2–5.

[5] JCS/J6, "C4I For the Warrior, Global Command and Control System—From Concept to Reality," 12 June 1994.

[3] Gen John Loh and MGen James Hobson Jr, *Final Multi-Command Operational Requirements Document (ORD) CAT-AFSOC TAF-340-88-I/II/III-B (Increment 2) for Wing Command and Control Systems (WCCS) ACAT Level II*, 22 June 1995, 3.

[4] Ibid., 3.

[5] Ibid., 1.

[6] Ibid., 16.

[7] Ibid., 17.

[8] Ibid., 40.

[9] Ibid., 45.

[10] HQ SSG, *GCSS-AF (BLSM II) Objectives,* Internet: http://HQSSG/proobs.html, 12 November 1995.

[11] Robert Frye, "HQ Standard Systems Group," briefing, AF/CE Automation Steering Group, 1 February 1996.

[12] Draft Program Management Directive, *Deliberate and Crisis Planning and Execution*, 15 November 1995.

[13] Civil Engineer Automation Steering Group, *Air Force Civil Engineer Automation Strategic Plan*, 20 September 1995, 1.

[14] SFC Tony R. Arnold and Fred Steinman, "Design at Your Fingertips: The Theatre Construction Management System," *Engineer* Volume 25 PB 5-95-3 (December 1995): 28–29.

[15] Col Rich Johnson, "Drawing the Lines in Bosnia," *The Military Engineer* No. 576 (February–March, 1996): 53–55.

Chapter 3

Methodology

Overview

The literature search confirmed that automation technologies can be successfully applied to processes similar to CE contingency planning and execution processes. Additionally, the literature search provided an understanding of specific tasks within the CE planning and execution process, and highlighted the myriad of C4I systems within which ACEPES must operate.

Unfortunately, the literature did not answer the main research question: *How can CE use automation to improve the contingency planning and execution process?* Similarly, the literature search did not answer the following subquestions:

1. What existing electronic information databases could be accessed to provide critical planning data?
2. What existing automated planning tools are available within the commercial and governmental sectors?
3. How should the best characteristics of existing systems and databases be applied within a new system to improve air base planning and execution methods?

This void in research knowledge was filled through the use of surveys and direct observation. Using a combination of personal interviews, telephone interviews, electronic mail and direct observation, the primary data for this research was collected. Surveys can be either interviews or questionnaires depending upon the survey strategy.[1]

These methods were used in lieu of written questionnaires based on the need to approach the data gathering process in an exploratory fashion. Additionally, personal or telephone interviews offer the researcher much more latitude, and a potentially deeper understanding, when dealing with exploratory research of a complex subject.[2]

The first step in the research effort was to understand the processes proposed for automation, down to the task level. The next step was to identify tools and information databases required to efficiently perform the tasks. Both the first and second research steps were accomplished through interviews and personal experience. The third and final step of the research effort involved analyzing the tools, databases, and technologies discovered against specific measurements of effectiveness such as speed, ease of use, cost, accuracy, and availability. If a particular technology product or database did not add to the efficiency or effectiveness of the planning and execution process, it was considered non-supportive.

Population and Sample

The population of interest for this research consisted of all automated contingency planning tools in use or under development, and all governmental or commercial personnel involved in air base or beddown planning activities. However, since no statistical inferences were to be made on the data, a sample consisting of major existing automated planning tools with a similar task objective, for example facility or air base development, was considered adequate. Similarly, a sample consisting only of sufficient data sources to validate the hypothesis that electronic data does exist and can be accessed was also considered adequate for the exploratory research desired.

Data for this research was collected from HQ Air Mobility Command Civil Engineer (HQ AMC/CE), Scott AFB, IL; HQ USAF/CEO, Washington D.C.; the Air Force Civil Engineer and Support Agency (HQ AFCESA), Tyndall AFB, FL; HQ Pacific Air Forces Civil Engineer (HQ PACAF/CE), Hickam AFB, HI; HQ Air Combat Command Civil Engineer (HQ ACC/CE), Langley AFB, VA; HQ Air Force Logistics Management Agency (AFLMA), Maxwell AFB, Gunter Annex, AL; Defense Mapping Agency (DMA), Washington D.C.; Environmental Systems Research Institute (ESRI); Science Application International Corporation (SAIC), Panama City, FL; ERDAS, Alexandria, VA; Wright Laboratory, Tyndall AFB, FL; RED HORSE Silver Flag Exercise Site, Tyndall AFB, FL; and the Internet.

A cross-sectional study is adequate for the needs of this research because it provides a snapshot in time of the characteristics of existing databases and planning systems that could be woven into development of a CE planning tool. The designers, operators and users of the systems and data sources researched in this project stressed that due to rapid increases in technology, automated planning tools are very dynamic entities. These tools must have sufficient flexibility to adapt to changing needs, an ever-increasing availability of new automated systems and data sources within other functional areas, and rapid technology changes. Based on this consensus, the data provided a sufficient basis to propose recommendations for an automated civil engineer tool.

The qualitative nature of the selected methodology was driven by the qualitative goal of the research—to aid in the development of an automated civil engineer tool. Quantitative research was ruled out because the opinions, ideas and free-thinking concepts needed to solve the problem are not quantitative in nature.

Collection of Data

Preliminary interview questions were developed based on information gained in the literature review and direct observation of several existing automated systems or systems under development. The systems observed or investigated included commercial and government software, information databases and C4I platforms.

The majority of the questions were intentionally open ended to allow the respondents the opportunity to bring out additional information. Although the preliminary questions were reviewed to ensure validity and reliability, several respondents surfaced additional facets of the development of automated planning tools that were beneficial to the research. For this type of exploratory research open, semi-structured questions are highly recommended.[3]

An additional motivation to use interviews in lieu of written questionnaires was the geographic closeness of several sources. HQ AFCESA/CEO, in charge of the development of new technologies for civil engineer application, and Wright Laboratory, in charge of the development of the Planmaster bare base software, are both located at nearby Tyndall AFB in Florida. Similarly, Silver Flag, the Air Force Civil Engineer Readiness Training Center, is located at Tyndall AFB. The Panama City office of SAIC, Inc. is also located near Tyndall AFB and is headed by the former Director of Readiness at HQ AFCESA. Lastly, nearby Gunter Annex is the home of the Air Force Standard Systems Group, in charge of the development of all Air Force specific software. Each of these organizations, offered much insight from both a developer's and user's perspective of the proposed automated system. All of the organizations noted above were personally contacted by the research team without the expenditure of limited travel funds.

Telephone interviews and electronic mail were also used to gather data from sources not highlighted above. Although personal interviews may have yielded additional data, the cost of travel outweighed the limited additional benefits of more data. The use of interviews, both personal and telephone, requires more time than other survey techniques and many more users could have been reached in an equivalent amount of time if a written questionnaire approach had been chosen. The use of written questionnaires was rejected however for two reasons. First, the goal of the research was to gather new ideas. Interview techniques offered the best means of accomplishing this task. Second, the depth and breadth of information obtained through interviews far exceeds that typically gained through written questionnaires.[4]

Immediately prior to this research effort, HQ ACC and HQ AFCESA developed and sent questionnaires to all Air Force MAJCOM Civil Engineers soliciting their inputs as to specific data is needed for an automated CE information system. The results of these surveys validated that Civil Engineers across the Air Force recognize the tremendous additional benefits that automation could bring to the beddown process. These surveys further validated that the specific data needed most by engineers during the beddown process is often difficult to access, incomplete or unavailable when needed.

A detailed listing of personal contacts made during the course of this research is included in Appendix B. The diversity of contacts, both in government and commercial industry, gave the research team a strong foundation in the areas of air base planning and execution, government and commercial software products, information databases, and automation and integration technologies. These organizations, now and in the future, will be the essential players in any automation product developed for the CE community. The

points of contact contained in Appendix B will serve as an excellent starting point for follow-on research efforts that advance our findings.

Summary

A review of books, periodicals and journals confirmed that automated tools are currently being used to improve processes very similar to the CE beddown processes. It also provided a general background knowledge of how technology could be applied to automate these processes. This background understanding, in addition to information gathered through surveys and direct observation, was used to answer the research questions.

Two distinct products will result from this research. The first product is a systematic and comprehensive review of existing technologies and developmental efforts targeted at air base beddown activities. The second product is a specific description of system characteristics, interfaces and functional relationships that an automated planning and execution tool must exhibit. The latter of the two products is framed in two separate implementation strategies—immediate to short term and long term.

Notes

[1] Emory, C. William, *Business Research Methods.* 3rd ed. (Homewood, IL: Richard C. Irwin, Inc., 1985), 202.
[2] Ibid., 203.
[3] Ibid., 203.
[4] Ibid., 160.

Chapter 4

Findings

Overview

Like any automation product, ACEPES will have to be built around information and information management. A key factor in the development of ACEPES will be the extent to which available data sources and automation software meets beddown planning and execution process requirements. This chapter documents our research findings by providing a systematic and comprehensive review of existing technologies and developmental efforts targeted at air base beddown activities. We focus on the two foundations of ACEPES—information databases and software applications.

In the process of providing this systematic review of existing technologies, we are able to answer the first two research questions. By exploring *types* of electronic data and data *sources* relevant to an automated air base planning tool, we answer: *What electronic information databases could be accessed to provide critical planning data?* By exploring existing *software* applications that can transform data into useful information for beddown planners and decision-makers, we answer: *What automated planning tools are available within commercial and government sectors?* In answering this second subquestion, we will show that a variety of Geographic Information System (GIS), GIS

derivative, and Database Management System (DBMS) software platforms exist that can perform some of the required tasks of ACEPES.

Data

The management of information is critical to successful CE contingency planning. No matter how powerful and capable an automation planning tool is, it can be no better than the data. Likewise, data must be readily available from established sources to avoid wasting limited resources. Perhaps most important however, is the requirement that data be both the correct type and from a reliable source. These two issues, data types and data sources were examined during the research and are presented below.

Data Types

In defining ACEPES data requirements, we must first establish what type of data is required to automate the beddown planning process and second, determine what level of accuracy or resolution is required. After working through the planning requirements and defining the processes, we determined that most data requirements center around global mapping information and logistical planning requirements. In short, we need data on where we are going, what needs to be deployed and how can we best deploy it. The research determined this information, or data, is usually be found in three basic types: spatial, image, and tabular. A depiction of how these three types of data could support CE contingency planning is shown in Figure 4-1.

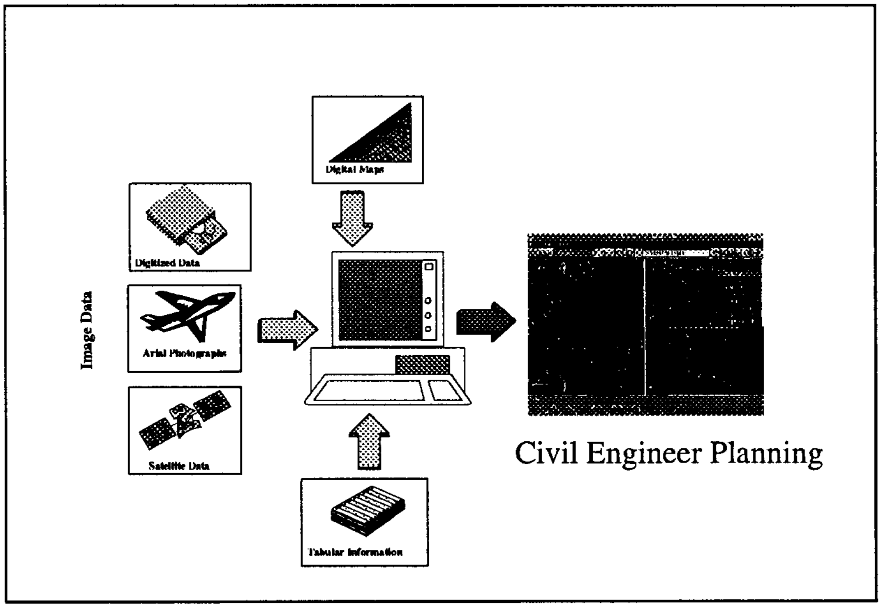

Figure 4-1. Data Types

Spatial and image data come in two formats: raster and vector. Both formats are common throughout the digital mapping industry, making it a core requirement for any system to be able to use both. Raster data is characterized by a matrix of rows and columns of picture elements (pixels). The pixel represents the value or color at a point while the position of the row and column correlates to the geographic position. Examples of raster data are satellite imagery and scanned pictures. Vector data is characterized by series of formulas that represent geometric shapes. CADD drawings and digitized base maps are familiar examples of spatial data in vector format. Failure to use both formats would severely limit ACEPES' ability to utilize existing mapping information and dramatically reduce the capability of the system.

Spatial Data. Spatial data is at the heart of a digital mapping system. Spatial data contains locations and geometric shapes of the map features. Spatial data includes points that define the lines that represent features such as runways, buildings and roads.

It also includes natural and administrative areas such as flood plains, borders and property lines.

Image Data. Image data is just as the name implies—data consisting of images. Image data is found in raster data format. Image data suitable to ACEPES comes in many forms including satellite imagery, aerial photographs, and scanned data (essentially image data that has been converted from printed to digital format).

Satellite imagery is valuable data because it can show relatively current conditions and resources at a given location. From satellite imagery CE planners can readily identify much of the information needed to support a force beddown. Examples include the size and capacity of an aircraft parking ramp, the area available to construct a tent city, and the location of existing base facilities and utilities. One subset of satellite imagery, often referred to as multi-spectral imagery, provides additional information such as ground slope, soil type and flood plain locations. Multi-spectral imagery is particularly useful to CE planners because it provides information that is normally only available by physically visiting the deployment location.

The most significant benefit of satellite imagery is that it adds valuable ground truth to the CE planning process. Maps generated from satellite images are richer in content since they contain valuable real world images and information. In this manner, satellite imagery is often used as a backdrop to provide a visual reference to vector data maps to facilitate planning and provide a means for fast updating.[1]

Aerial photographs provide many of the same benefits as satellite imagery. The primary difference between the two is that aerial photographs are taken at significantly lower altitudes and thus, resolution (or image clarity) is usually higher. Obtained from

platforms such as the U-2, resolution of aerial photographs is often recorded in feet or inches while most satellite resolution is recorded in meters. Reconnaissance aircraft are also capable of providing stereographic images. These special images, recorded from two cameras on the same platform, add a three-dimensional effect to the image data. This three-dimensional effect allows computation of not only the size of structures within the image, but also the height of the structure.

Determining the appropriate imagery resolution sufficient for accurate and effective CE contingency planning was a critical issue in the ACEPES design. The correct resolution of imagery is critical to ensure the planner is able to see pertinent objects in the image and base planning decisions on accurate dimensions, locations, and other image data. Resolution of raster images is a function of the ground cell sample size each image pixel represents. For example, if each image pixel represents a ground cell sample of ten by ten meters, then objects less than ten meters cannot be distinguished from their background. This becomes critically important in determining reference points such as the edges of airfield pavements.[2]

In order to determine what image resolution CE planners need, we reviewed each planning activity within the process to determine which activity has the most restrictive tolerance for measurements. Placement of aircraft on the airfield proved to be the most restrictive planning activity. This conclusion is supported by the fact that the airfield has finite dimensions and the aircraft being supported by the beddown process are high-cost assets with very specific criteria for clearances. Attempting to determine the edge of an aircraft parking ramp from a satellite image with ten-meter resolution could result in an

error of almost 70 feet if the perceived edge of the pavement is off by a single pixel on either side.

We reviewed numerous satellite images to get a hands-on feel for the resolution required to place aircraft on a parking ramp while meeting physical and operational constraints and criteria. Five meters is the lowest resolution that will work for determining the edge of the airfield pavements. However, the most desirable resolution for determining dimensions for airfield pavements was in the range of one to two meters.

For most functions, ACEPES will require imagery with one- to five-meter resolution. However, the fact that a specific planning function (i.e. parking plans) requires one-to two-meter resolution does not mean that lower resolution imagery does not have applicability for functions such as determining vegetation and ground slope at a potential beddown site. For this type of application, 20- to 30-meter multi-spectral imagery is well suited.

It should be noted that high resolution imagery requires a significant increase in computer memory capacity and also has a direct impact on computer performance. The relationship between image resolution and image data size, in computer bytes, is linear. As the resolution of an image doubles, for example goes from ten-meter to five-meter resolution, the amount of image data requirements increases by a factor of four.[3] To put this in perspective, if a ten-meter resolution image requires two megabytes of storage, a five-meter resolution image of the same area will need eight megabytes. This is an important factor to consider when selecting hardware components for ACEPES. Samples of satellite imagery are provided in Appendix C.

Tabular Data. Tabular data is descriptive data that is linked to map features and provides the intelligence behind the map. Tabular data is collected and compiled for specific areas and is often packaged with spatial data. Geographic information such as latitude and longitude, clear zones, and noise contours are examples of tabular data. Other examples include airfield features with basic descriptions and dimensions.

Data Sources

There are several sources where data can be obtained. These sources have been categorized into two areas and are depicted in Figure 4-2. Federal agencies, such as the Defense Mapping Agency (DMA), are excellent sources of mapping and satellite imagery products critical to the Civil Engineer planning process. Commercial sources provide data such as multi-spectral imagery from the Landsat satellite constellation providing information on terrain and site composition. In addition, private companies specializing in satellite imagery and geographic information systems have large amounts of data available through the Internet.

Where external federal agencies or commercial sources do not have the necessary data needed for CE beddown planning, the information will have to be generated within the Air Force. This data will come from site surveys of the area of interest, existing OPLANs, or contracting initiatives with consultants to develop a specific database needed to fulfill a specialized CE requirement.

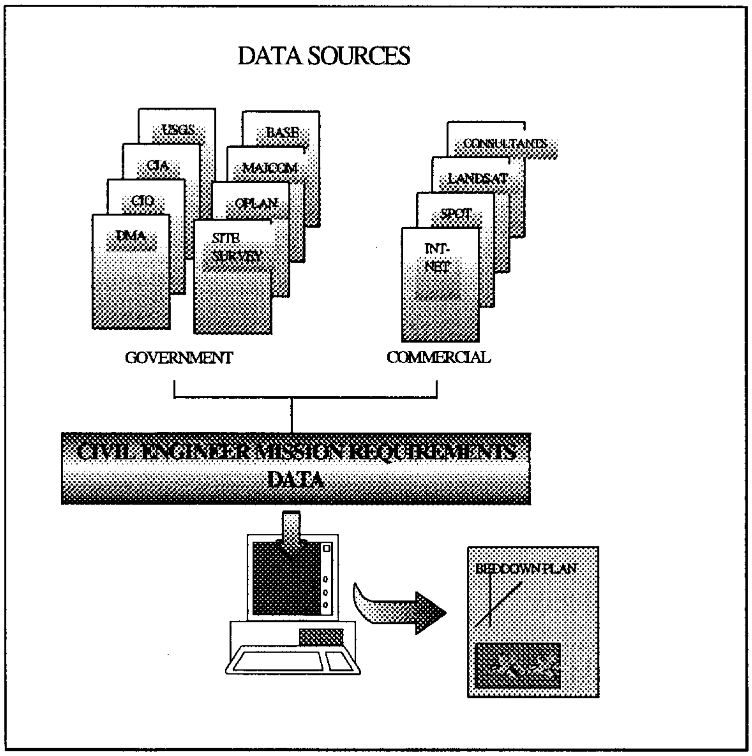

Figure 4-2. Data Sources

Federal Sources. The methods and sources we currently use to obtain information are changing with technology. In fact, much of what was discovered in this research effort will have changed by the time a long-term ACEPES is implemented. Perhaps the most significant anticipated change is driven by the Secretary of Defense's announcement of the creation of a National Imagery and Mapping Agency (NIMA).[4] NIMA will consolidate imagery, mapping resources, and related management of those resources into a single organization under the Department of Defense. The purpose of forming the new organization is to improve the overall effectiveness of imagery intelligence and mapping support the military and other national customers.

Specific details of the new agency are still being developed, but it is expected that NIMA will be formed by consolidating the DMA's Central Imagery Agency, the Central Intelligence Agency's National Photographic Intelligence Center, the Defense Intelligence

Agency's imagery support function, and elements of the Defense Airborne Reconnaissance Program. NIMA will be designated as a combat support agency under the DOD and has a projected standup of 1 October 1996.[5] NIMA, as presently envisioned, will have significant impact on how we currently obtain mapping and imagery information in that there will now be a single agency for "one stop shopping."

Defense Mapping Agency. Currently, DMA is the primary collector and repository for maps and digital spatial data. DMA is a major DOD combat support agency and provides global geospatial mapping information and services to all elements of the DOD and offices of the federal government. As the GCCS executive agent for mapping, charting, geodesy and imagery (MCG&I), DMA has a major influence in how the military exploits geospatial information in the command & control and deliberate planning processes. DMA's goal is to provide unclassified, ten-meter resolution, worldwide satellite imagery by the year 2000.[6] The planner will be able to access this data through GCCS via the classified military channel of the Internet.

DMA is equipped with some of the most sophisticated electronic cartographic and photogrammetric equipment in the world. The agency provides paper maps and charts as well as digital data to support the US military. In support of the military alone, the agency produces more than 26 million copies of maps and charts yearly and has a large variety of digital mapping products. These products will be primary data inputs to the automated beddown planning process.

The digital mapping products that DMA currently has available or under development are listed in Table 4-1. Of these products, those with the most applicability to ACEPES are the Joint Mapping Tool Kit (JMTK), Digital Chart of the World (DCW),

and the Digital Automated Air Facilities Information File (AAFIF). These products were further explored and our findings are provided below. Other DMA products were reviewed and considered inapplicable for ACEPES because they are primarily geared towards global navigation and were not to the scale or resolution needed for accurate CE planning.

The Joint Mapping Tool Kit is the single most promising DMA product in existence or in development in terms of support to contingency planning. The JMTK will perform key functions in the Defense Department's Global Command and Control System. As the GCCS mapping software, JMTK will provide a common interface allowing each of the services to access and share the same data. The JMTK has successfully completed design and soon will be integrated with other elements of GCCS.[7]

Table 4-1. Digital Products

Existing Digital Products	Prototype Digital Products
ARC Digitized Raster Graphics (ADRG)	Joint Mapping Tool Kit (JMTK)
ARC Digital Raster Imagery (ADRI)	Controlled Image Base (CIB)
Automated Air Facilities Information File (AAFIF)	Controlled Multi-spectral Image Base (CMIB)
Compressed Aeronautical Chart (CAC)	Compressed ARC Digitized Raster Graphics (CADRG)
Digital Aeronautical Flight Information File (DAFIF)	Compressed Raster Graphics (CRG)
Digital Bathymetric Data Base (DBDB)	Electronic Chart Updating Manual (ECHUM)
Digital Feature Analysis Data Level 1 (DFAD1)	Digital Gazetteer (DG)
Digital Feature Analysis Data Level 1-C (DFAD1-C)	Digital Sailing Directions (DSD)
Digital Feature Analysis Data Level 2 (DFAD2)	Digital Topographic Data (DTOP)
Digital Feature Analysis Data Level 3-C (DFAD3-C)	Interim Terrain Data on CD-ROM (ITD-CDR)
Digital Terrain Elevation Data Level 1 (DTED1)	Tactical Terrain Data (TTD)
Digital Terrain Elevation Data Level 2 (DTED2)	Vector Smart Map Level 0 (VMap0)
Digital Nautical Chart (DNC)	Vector Smart Map Level 1 (VMap1)
Interim Terrain Data (ITD)	Vector Smart Map Level 2 (VMap2)
Mapping Datum Transformation Software Program (MADTRAN)	Vector Smart Map Urban (UVMap)
Mapping, Charting & Geodesy Video Laser Disc (VLD)	World Vector Shoreline-Vector Product Format (WVS-VPF)
Navigation Information Network (NAVINFONET)	
Probabilistic Vertical Obstruction Data (PVOD)	
World Mean Elevation Data (WMED)	
World Vector Shoreline (WVS)	
Digital Chart of the World (DCW)	

The Digital Chart of the World (DCW) is a 1700-megabyte database of vector geographic information. It provides global coverage of topographic information equivalent in detail to a 1:1,000,000 scale map. Furnished with DCW is application software, and its source code written in C language, designed to operate on MS-DOS

based microcomputers. UNIX application software is also available. Each DCW data library contains seventeen thematic layers. DCW covers North America, Europe, Asia, South America, Africa, Antarctica, and Australia. The application software, VPFVIEW, distributed with DCW allows display of selected combinations of features and themes for a user-selected geographic area of interest. DCW is the first major data set published in compliance with the Digital Geographic Information Exchange Standard (DIGEST).[8]

AAFIF is a flight information database containing airport, runway, navigational aid, enroute and terminal data including both the high- and low-altitude enroute structures. The product has great applicability to ACEPES because it provides general information on worldwide airfields including location and size.[9] The database consists of the following records:

> Airport records, which contain names, [International Civil Aviation Organization] ICAO and/or [Federal Aviation Administration] FAA code, geographic coordinates, elevation type airport, and datum information on all active airports that have a usable permanent runway surface. Hard surfaced heliports/helipads that are listed in paper. Flight Information Publications (FLIP) Runway records, which contain magnetic heading, runway width, surface, length, elevation, and slope information. Arresting gear information for the above runways.[10]

DMA plans to stop many of its press operations as it continues to move into the digital era. The Agency wants to end the practice of creating quantities of map sheets that ultimately end up unused on shelves in a warehouse. DMA is moving toward a digital warehouse where products and services will be available on demand. DMA's customers will be able to remotely access the DMA database and download the data needed to support their operation. DMA data products, their resolution, and applicability to ACEPES are shown in Table 4-2.

Table 4-2. Data Products

Source	Product	Collection System	Resolution/ Scale	Applicability to ACEPES
DMA	Joint Mapping Tool Kit	Digitized products compiled by DMA	10 meter	**High**—High applicability but currently still in development. Will be integrated with GCCS and accessed via classified Internet (SIPRNet)
DMA	Digitized Map of the World	Digitized Maps compiled by DMA	1:1,000,000	**Medium**—Scale does not lend itself to use by ACEPES except for regional planning.
DMA	Automated Air Facilities Info File	Tabular information on airfields	N/A	**Medium**—Provides generic information about airfields length, ramp space, etc.
DMA	Satellite Imagery	National Assets SPOT Landsat	Less than 10 meter 10 meter 30 meter	**Medium**—Has a great deal of imagery but not presently in a common library. Initiatives are under way to correct this. 5-meter resolution imagery on CD-ROM is starting to become available and higher resolution will eventually be available through classified Internet.
DIA/DMA	Satellite Imagery	National Assets	Less than 10 meter	**Medium**—Can be requested and accessed through the intelligence community. Many of the images will be classified depending on the resolution and location of the image.
SPOT	Satellite Imagery	Commercial Satellite	10 meter	**Medium**—DMA normally procures for the DOD
Landsat	Satellite Imagery	Multi-Spectral Satellite	30 meter	**Medium**—DMA normally procures for the DOD

Source	Product	Collection System	Resolution/ Scale	Applicability to ACEPES
Russian Space Admin.	Satellite Imagery	Film Recovery	2 meter	**High**—Can be purchased through the Internet.

Commercial Sources. The most promising commercial sources of data for ACEPES application include Satellite pour L'Observation de la Terre (SPOT) satellite imagery, Russian Federation satellite imagery, and the Internet. Each of these sources has relative benefits depending upon criteria such as availability, cost, resolution and format. While DMA is the military focal point for most imagery, some of this data is sourced through commercial avenues. The last three entries of Table 4-2 contain the resolution and applicability to ACEPES for commercial data sources. Background information is provided below for each of these commercial products.

SPOT Imagery. SPOT Image Corporation is a commercial provider of detailed satellite imagery with worldwide coverage. SPOT imagery is collected by three French satellites which provide panchromatic (black and white) imagery down to ten-meter resolution. The company can also provide three-band multi-spectral images with 20-meter resolution, including infrared. SPOT provides a full range of satellite imagery in digital and visual formats and is planning to launch a new satellite in 1999 to provide five-meter panchromatic resolution and ten-meter multi-spectral imagery.[11]

SPOT's satellite imagery is available over the Internet. Imagery from SPOT's archives can be delivered within two hours but if unavailable in the archives, delivery can take several days. This capability could prove significant when responding to emergencies or short-notice deployments. A benefit of commercial imagery, such as

SPOT, is its unclassified nature which removes cumbersome security requirements normally associated with imagery from U.S. national assets.

Russian Federation Imagery. Another source of satellite imagery is that provided by the Russian Federation. Russia, through the Russian Space Agency, permits the sale of commercial satellite imagery. Currently, two-meter resolution is available but one-meter resolution is being considered. The main attraction of the Russian products is their tremendous resolution for mapping applications. The camera provides 80 percent overlap between images along with internal and external elevation. This imagery is available through a number of commercial contractors in the U.S., one of which is Intermountain Digital Imaging, a company that takes orders over the Internet.[12] The acquisition time for film imagery from Russia is considerably longer than digital imagery systems such as SPOT. Although archived imagery can be delivered to the customer in a matter of days, orders for new imagery must be placed months in advance.

Internet. From the Internet, a CE planner can access real-time weather data, satellite imagery, online technical support for computers and software, and airfield capabilities to name a few. Major information collectors and providers, such as DMA, are turning to the Internet as a primary means of disseminating information to its customers. Advances in technology have also enabled the exchange of classified information through the Internet. The intelligence agencies and DOD currently have or will have access to classified Internet resources such as the SIPRNet. Numerous web sites that are of benefit to CE planners are provided in the bibliography.

Software

Overview

After defining ACEPES requirements and identifying data sources, existing commercial and government software applications were evaluated against the defined needs. Existing applications are relatively broad and will be able to meet many of ACEPES requirements. Standard commercial programs such as office suites, database management, CADD and Geographic Information System (GIS) applications are flexible, open systems which serve as capable applications for an automated planning tool. In addition, government software applications have been developed which address specific beddown planning functions. The remainder of this chapter is dedicated to our findings with respect to a series of promising GIS, GIS derivative, and DBMS software applications. The applications reviewed, and their terminology references, are highlighted in Table 4-3.

Geographic Information Systems

A geographic information system is a computer system capable of assembling, storing, manipulating, and displaying geographically-referenced information. GIS technology is primarily for facility and resource management, community planning, and scientific investigation. For example, a GIS would allow military planners to quickly calculate aircraft parking plans using layered geographic map data, relational databases, customized macros, and analytical vector capability. Similarly, a GIS might be used to find the best locations to beddown forces considering such things as flood plains and clear zones using the same capabilities.

Table 4-3. Software Applications

Software Category	Short Name	Full Name
Geographic Information Systems (GIS)	Intergraph AutoCAD ARC/INFO	• Intergraph MGE • AutoCAD ADE—AutoCAD Data Extension • ESRI ARC/INFO and Arc/View
GIS Derivatives	IMAGINE CRISIS REACT EIS	• ERDAS IMAGINE • Combat Readiness Infrastructure Support Information System • Rapid Emergency Assessment and Contingency Toolkit • Emergency Information System
Database Management Systems	Planmaster AutoACE JLEB ECLiPSE BCAT	• Planmaster • Automated Airbase Contingency Estimator • Joint Logistics Electronic Battlebook • Enhanced Contingency Logistics Planning Support Element • Beddown Capability Assessment Tool

The biggest advantage of GIS systems is that they allow leaders to make intelligent decisions using two- and three-dimensional graphics dynamically linked to vital information and analytical tools. The database management and analysis functions of a GIS, combined with CADD, are key elements of an automated CE planning and execution system.

Our research effort discovered that three commercial GIS software developers dominate the market: Intergraph Corporation, Autodesk Corporation, and Environmental Systems Research Institute (ESRI), Incorporated. One of the research sources included a very useful evaluation matrix published by GIS World Sourcebook. The Sourcebook includes an excellent appraisal of over 300 GIS software products measured against a comprehensive evaluation criteria of over 30 categories. Appendix E includes excerpts pertaining to commercial GIS products evaluated in this research effort, which are discussed below.

Intergraph MicroStation Graphics Engine. Intergraph Corporation is one of the world's largest companies dedicated to supplying interactive computer graphics systems.[13] Of particular interest to ACEPES are Intergraph's GIS and CADD products which the company calls MicroStation Graphics Engine (MGE), and MicroStation. Intergraph has recently packaged these two products in software suites called GIS Office and Mapping Office. GIS Office is a high-end software suite with an extensive GIS and CADD capability. Mapping Office is a less capable suite which provides an entry level GIS and CADD capability. Mapping Office is upgradable, enabling an organization to expand to GIS Office if its GIS requirements grow. Both software suites use Intergraph's CADD program, MicroStation, as a core operating platform.

MGE has a full range of imaging products geared to support a wide range of user applications to include mapping, engineering design, project planning and layout, and remote sensing. Intergraph's new line of imaging products for Windows 95 includes the capability for basic hybrid image vector display, image enhancement, registration, and plotting. MGE Base Imager (MBI) includes all of these basic features plus a greater assortment of color image enhancement features and a complete set of gray-scale image processing tools. The software has a library of batch processing routines, a record and playback feature, and a programmer's toolkit to support customized development of raster-based applications. MGE Advanced Imager is an add-on module which complements MBI with a complete set of tools for color image manipulation, and multi-spectral image processing and post processing. Intergraph's imaging applications can run standalone or integrated with all other applications in the MGE product suite.[14]

Intergraph's software suites are CADD-based and use an open system architecture. The nonproprietary format makes the sharing of information easier and eliminates the need for translation back and forth between formats. Intergraph's use of common source code enables its software to run on Windows 95, Windows NT and UNIX systems. MGE and MicroStation can also be network based.

An advantage of Intergraph's Office Suites is that MicroStation is one of the two systems (AutoCAD being the other) used by Civil Engineers at our main operating bases. As a result, those bases who are already using Intergraph will have an existing knowledge base and will not have to learn a completely new software program. Intergraph's CADD program, MicroStation also has the ability to read and write to AutoCAD drawings.

One of the most attractive features of MGE imaging software is that it has recently been made available to run on Microsoft's Windows 95 operating system, as well as on Windows NT. Civil Engineers are currently undergoing an Air Force–wide local area network (LAN) conversion based upon the Microsoft Windows operating system.

Additionally, Intergraph's products can be run on a laptop computer; this is essential for a deployable system. However, because of the graphical requirements of GIS systems, not all laptop computers will be able to produce satisfactory displays. Laptops with Super Video Graphics Array (SVGA) displays are required with no less than two megabytes on the graphics cards.

AutoCAD Data Extension. Autodesk Corporation's AutoCAD has over a million users, making it one of the CADD/GIS industry leaders.[15] Since AutoCAD's first installation in 1980, thousands of military installations and architect, engineer and construction firms have automated their design and drafting process with AutoCAD

software. AutoCAD users greatly benefit from the advantage stemming from abundant industry market share. The advantage translates to increased productivity for file transfers/exchanges and drawing detail sharing. AutoCAD Data Extension (ADE) expands AutoCAD's basic single workstation CADD function into a multi-user enterprise GIS system. ADE can link drawings and data to manage base beddown process from layout planning to design and construction management.[16] AutoCAD Version 12 and ADE have drawbacks with relation to ACEPES use: namely limited spatial data exchange capabilities, raster/vector integration and digital image processing.[17]

Part of AutoCAD's desirability stems from over 5,000 independently developed add-on applications that enhance its effectiveness in a multitude of design, drafting and site planning functions. Many of these CADD functions and "add-ons" are the fundamental engineer automation tools used to quickly, efficiently and effectively lay out a bare base plan. Two of those add-on applications, CRISIS and REACT, were evaluated and are presented later in this document.

ARC/INFO. ARC/INFO is a series of six integrated software modules which combine basic GIS tools and utilities for cartographic design and query, data entry and editing, raster and vector data translation, polygon overlay and buffering, network analysis and modeling. ARC/INFO is a vector-based GIS, but the newest version includes a package called GRID which allows raster manipulation and some elementary image processing capabilities.

ArcView compliments ARC/INFO by adding desktop mapping and GIS tools that enables users to quickly select and display different combinations of data analysis. ArcView integrates traditional information analysis tools, such as spreadsheets, DBMS,

and business graphics, with maps, providing organizations with a complete set of tools to explore and analyze the geographic context of their information. By combining the power of visual map displays with information analysis tools, organizations will be able to make more informed decisions by understanding not only what their data represents, but where it is and why it's there.

In order to have the CAD capability that ACEPES requires, a user must have AutoCAD and a GIS interface program. ARC/INFO uses ArcCAD as the interface to create spatial database relationships and communicate with an AutoCAD drawing database.

ARC/INFO is an extremely capable and versatile program. However, this versatility results in the program being somewhat complex and difficult to operate. Technicians at DMA[18] and the US Army's Topographic Engineering Center[19] are very satisfied with what ARC/INFO can do, but maintain the program is not user friendly.

GIS Derivatives

In addition to the full-featured GIS systems previously evaluated, other software applications offer specialized GIS capabilities. We refer to these products as "GIS derivatives." This category includes software incorporating mapping and geospatial technologies, but in a more limited scope than previously described CAD/GIS products. Some GIS derivatives are referred to as "add-ons" because they are designed similar to macros which record an application's internal commands to customize the host program. The four products below highlight the potential of GIS derivatives to meet ACEPES requirements.

Combat Readiness Infrastructure Support Information System (CRISIS). CRISIS is a DOS and UNIX based computer product developed by the U.S. Air Force Academy that performs three separate functions. It is a CADD tool for Base Comprehensive Planning (BCP); an Air Base Operability (ABO) program used to display, evaluate, and teach base combat support concepts; and a wing commander's program used to electronically display base asset information.[20]

Marketed mostly for its BCP capabilities, CRISIS allows base planners to develop a base layout including airfield systems, facilities, and utilities. Satellite imagery can be used as a backdrop while developing CADD drawings of the base. The system also provides pre-attack planning (camouflaging, hardening, dispersal), base recovery after attack, and resource management capabilities. Originally developed in the 1980s, it has been used by various commands for training and operational purposes. Its largest supporter, Air Combat Command, approved its use as the standard for all ACC bases in 1992; however, the command withdrew this support in 1994 as the system demanded too much computer memory, was too slow, did not meet Tri-Service CADD/GIS specifications, and was too difficult to learn and keep experienced people proficient.[21] Furthermore, its use at Silver Flag for training was discontinued because it took too long to teach students how to operate, it was very slow, and its plotting capabilities were not logical to standard plotting procedures used by AF site developers (for example, plotting a runway was accomplished from the middle of the runway versus the accepted practice of starting from a corner point). Lastly, CRISIS is a "dead program" as it does not operate with upgrades in computer operating systems without a rewrite.[22] The USAF CE Automated Steering Group discontinued AF support for CRISIS in 1995.[23]

Rapid Emergency Assessment and Contingency Toolkit (REACT). REACT is an AutoCAD Version 13 wrap-around product currently under development by Science Applications International Corporation (SAIC). It will provide Air Force Civil Engineers tools to graphically track damage and recovery operations in the event of a natural disaster or combat attack. Data and maps used to track resources, damage, and recovery will be stored in a Microsoft Access relational database. Maps will be imported via digitized products, satellite imagery through third-party AutoCAD applications or AutoCAD-formatted maps. The system relies totally on such maps and must contain information loaded against images on the maps to be able to track damage/repair against such objects. Users will be able to prioritize repairs, track recovery actions, manage resources, and generate reports through this product.

Emergency Information System (EIS). The Emergency Information System (EIS) represents a family of computer and communications software focused on environmental management and emergency response. While EIS is not the full-featured GIS needed for mapping and bare base comprehensive planning, its capabilities are quite powerful for its intended purpose—crisis management. EIS/InfoBook employs a simple-to-use, tabbed three-ring binder format as shown in Figure 4-3.

Underneath its normal notebook appearance are detailed answers within each section blending data, maps, models and communications. The nine sections support the essentials of crisis management command and control. EIS capabilities are reflected by its popularity ranging from the Federal Emergency Management Agency (FEMA) and over 1600 state, city and county emergency management agencies.

However, EIS drawbacks with respect to ACEPES are significant and include limited GIS/mapping functions, limited spatial data exchange capacity, and limited data management exchange architecture. Overall, EIS addresses only a relatively focused subset of the ACEPES tasks. Base recovery and crisis response are obviously critical tasks, but rely on maps and data compiled throughout the beddown process.

Since EIS is not conducive to CADD/GIS-intensive tasks, the data (maps and tabular) compiled will be in a separate database from EIS. Considering EIS' internal database management structure and reliance on manually-scanned or vendor-supplied maps, EIS data collection and input will duplicate effort and introduce data discrepancies to ACEPES.

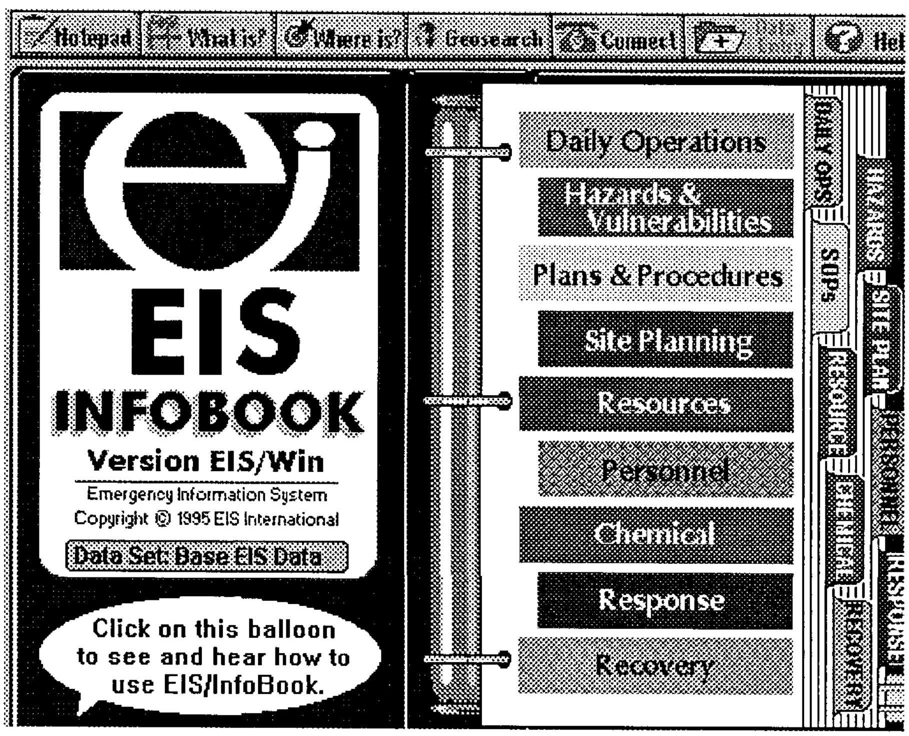

Figure 4-3. Emergency Information System

ERDAS IMAGINE. ERDAS IMAGINE is a COTS image processing and GIS software package that allows visualization and analysis of geographic information. The

software can be applied to highly detailed imagery gathered from satellites and aircraft, along with data from other remote sensing devices. IMAGINE software can geo-reference raw digitized imagery and merge images of various sources. IMAGINE is one of the industry's leading imagery software packages. Its vector capability is not as robust as ESRI software, but it incorporates ARC/INFO coverage for analysis of geographic information in the IMAGINE VISTA and IMAGINE PRODUCTION product lines. ERDAS IMAGINE and ESRI ARC/INFO capabilities are complementary to each other. IMAGINE add-on modules include additional ARC/INFO interfaces and a virtual 3-D GIS application that offers real-time fly-through visualization and analysis. A whole host of additional add-on modules are available. ERDAS IMAGINE is hardware independent, supported on all of the industry's most popular platforms (Sun, HP, IBM, etc.), and built on industry standard interfaces (X-Windows/Motif, Microsoft Windows NT and Windows 95). No special purchases are necessary.

The primary advantage of IMAGINE is its ability to process and analyze imagery faster and more accurately than vector-based software packages. Also, can produce professional quality hard-copy map output and graphic presentations. IMAGINE site licenses exist at many Air Force agencies for intelligence and targeting applications and at Army agencies for terrain analysis, flood control, emergency management and environmental applications. The Defense Intelligence Agency is currently supporting two contracts (C4I and the System Acquisition Support Services) that may offer site licenses at highly desirable prices. IMAGINE and ARC/INFO permit custom applications of these GIS platforms. The Army's Topographic Engineer Center at Ft. Belvoir, VA, has

developed custom macro routines to assist the Army in site selection, imagery database generation, and terrain visualization—functions that could be equally useful for ACEPES.

Database Management Systems

Decision support is one of the main purposes of database management applications. Database management applications automate decision support by storing data and their relationships, accepting human input variables, manipulating data into useful information, and reporting the results. The following applications provide decision support for various portions of the beddown planning and execution system. Our research evaluates the products' characteristics, performance and potential as an ACEPES component.

Planmaster. Planmaster was designed to provide beddown planners with a Windows-based system for deployment mission and site and analysis and for calculating beddown requirements. The DBMS application, contracted through Wright Laboratory's Air Base Systems Branch at Tyndall AFB, intends to:

> . . . permit planners to control the bare base planning process, [provide] supporting analytical tools to help planners balance among schedule, performance and resource parameters, and specify a construction management and scheduling routine to generate the list of materials, equipment and manpower required and the deployment time-phasing.[24]

The project completed a Phase I prototype demonstration and is scheduled to deliver Phase II in May 96. Without the final product, a complete evaluation for this research was not possible, however a rudimentary assessment is offered here.

Planmaster, based on AFPAM 10-219, will calculate bare base beddown requirements while accounting for mission, base regional location and existing facilities. The program facilitates a planner in generating a deployment and construction management plan including required manpower, materials, equipment, prioritized tasks and schedule.[25]

Planmaster's flexibility will allow planning and execution modifications without starting over in a predefined planning process. Appearing as a tabbed notebook, as shown in Figure 4-4, planners can "flip" to any of the seven tabbed sections as modifications are desired.[26] The application also includes tools for viewing and editing planning factor tables as changes occur in policies, equipment, practices and guidelines.[27] Application data tables will interface with other software through its open database conventions.

Planmaster provides selections for varying conditions by allowing the planner to select appropriate criteria such as special considerations, general assumptions, and environmental conditions.[28] A dialogue routine will assist with this process to ensure an important selection affecting beddown requirements or scheduling is not overlooked.[29]

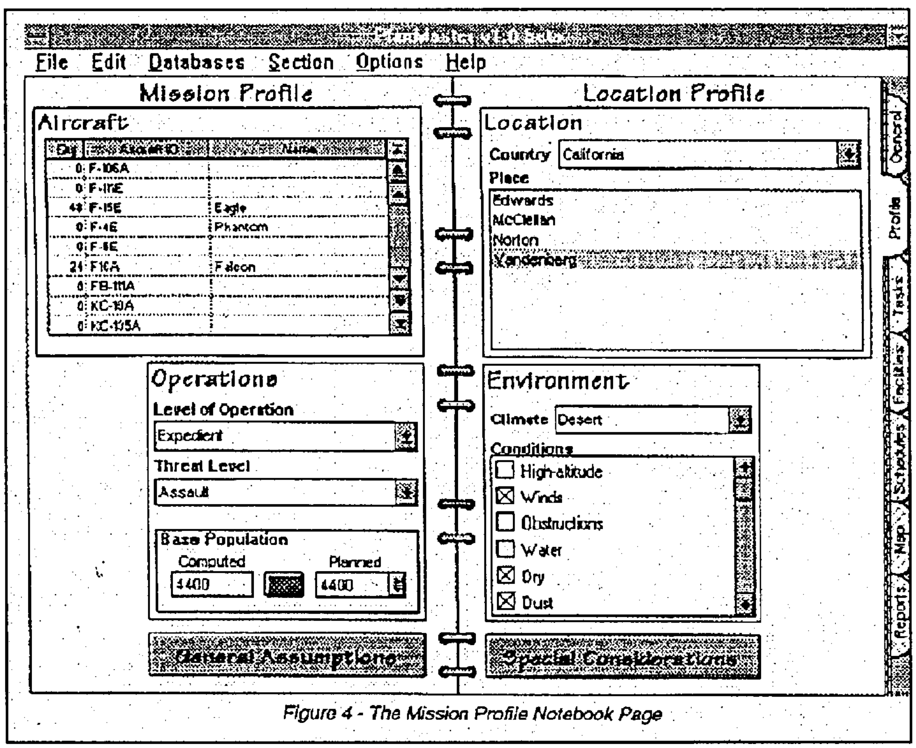

Figure 4-4. Planmaster Mission Profile Page

Joint Logistics Electronic Battlebook (JLEB). United States Atlantic Command developed this DBMS to automate Joint Logistics (J-4) crisis action and deliberate

planning through all stages of the Joint planning cycle. JLEB includes a logistics database for individual engineering, maintenance, services, supply, and transportation units for all services, including Active Duty, Reserve, and National Guard. Another key database feature tracks points of contact for joint, federal, and allied operations centers for each type of unit capability, equipment, and consumables.

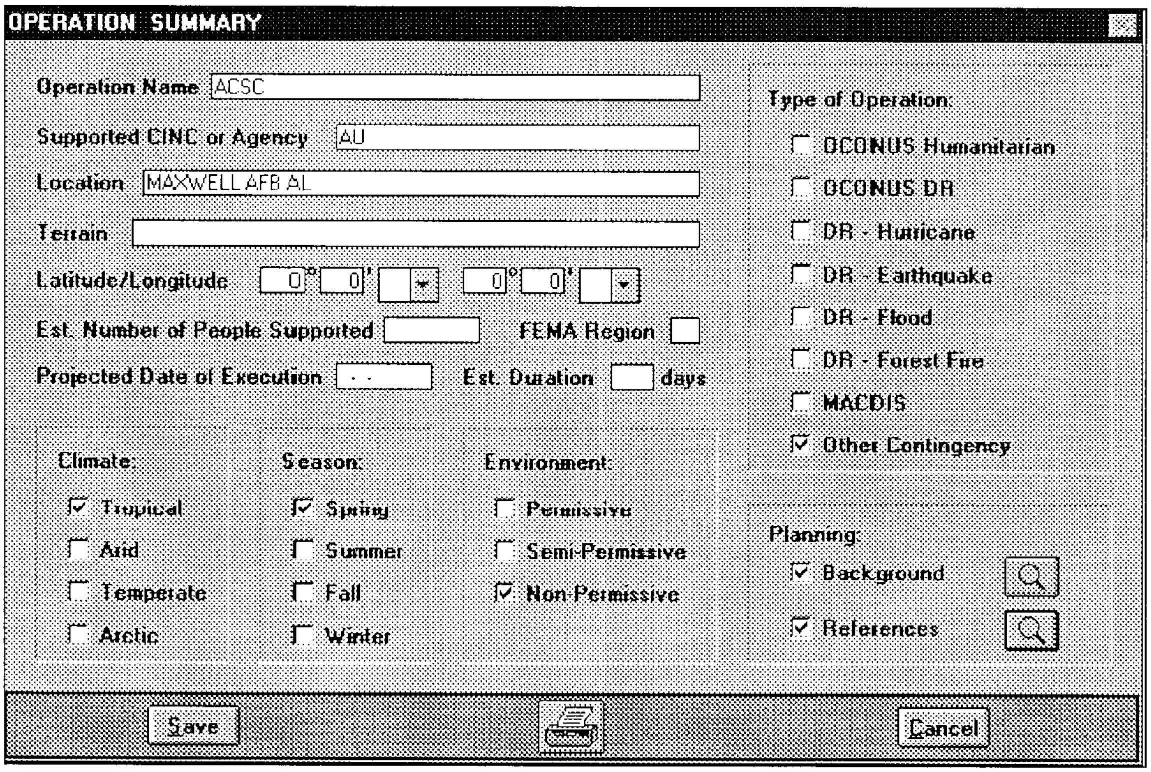

Figure 4-5. JLEB Operation Summary Input Screen

Figure 4-5, depicts the initial contingency planning options available within JLEB. The program assists the logistics planner with crisis action and deliberate planning by defining requirements based upon type of operation, location, number of people supported, duration, and other factors. Various planning functions and factors are used to calculate requirements and provide a basis for unit taskings. JLEB provides an evaluation of each mission area by capability with a color-coded (red, amber, green) status at all

levels of detail. A depiction of the JLEB mission evaluation screen is provided in Figure 4-6.

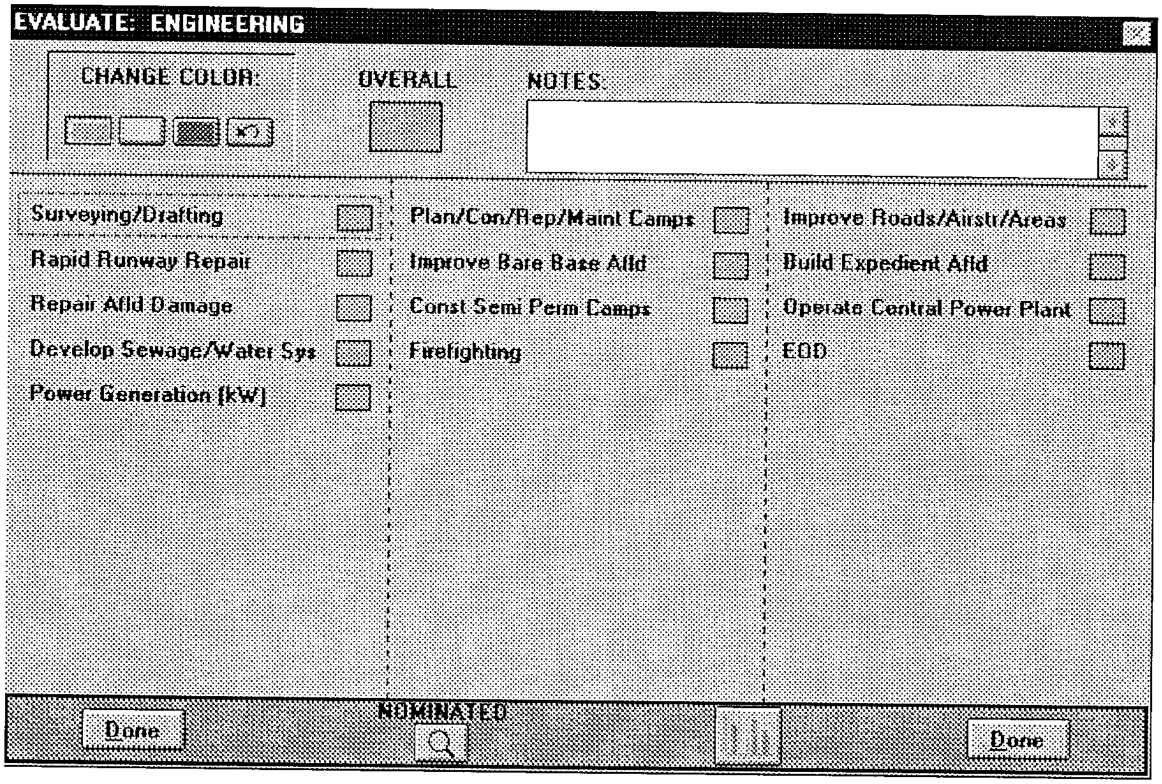

Figure 4-6. JLEB Requirements vs. Capabilities Evaluation Screen

JLEB models several good characteristics for ACEPES. The program could be adapted by a MAJCOM to customize their specific engineering capabilities across the spectrum of potential operations. Its level of detail into specific equipment requirements and unit capabilities could provide support for engineering and logistics planners as host-unit or host-nation assistance is arranged.

JLEB is a DBMS application which conforms to open database conventions, allowing interconnectivity to other database applications. The program allows considerable flexibility by granting edit capability to all planning factors, specific

operation requirements and color-coded evaluation weights. Report printing is available for all levels of detail.

Enhanced Contingency Logistics Planning Support Environment (ECLiPSE). The Air Force Logistics community has several well-established automation efforts underway, including ECLiPSE. As stated in Armstrong Laboratory's Internet Project Description,

> ECLiPSE will be developed in a two-pronged approach. One prong will rigorously analyze the current wing-level deployment process for shortfalls and weaknesses. State-of-the-art technologies and process-oriented solutions to these problems will also be applied and demonstrated.
>
> The other prong will demonstrate the technical feasibility of using leading-edge software technologies to remedy a weakness found in the deployment planning process during a preliminary ECLiPSE study. Based on this cursory study, a sub-set of ECLiPSE, the Deployment Information and Simulation Environment (DISE), is being developed. DISE will consist of: a centrally located knowledge base (KB) that will store a deployment site map, a site survey, lessons learned, and related war reserve material information; a component to assist planners in collecting deployment site information to populate the KB; and an analysis tool to evaluate all the available information to analyze beddown requirements with respect to beddown site resources.[30]

DISE has two major components or modules. One component addresses pallet optimization, and is named the Unit Type Code-Development, Tailoring and Optimization (UTC-DTO) module. The second module is for deployment site analysis and is referred to as the Beddown Capability Assessment Tool (BCAT). ECLiPSE communications hardware interconnectivity will provide deploying units use of DISE software modules and information databases either at their home station or deployed location.

Some BCAT functions overlap proposed ACEPES functions. Although there may be overlap, the total ECLiPSE system will provide some important communications, information management and decision support capabilities. The best USAF/DOD

solution will result from a coordinated ECLiPSE/ACEPES approach. Figure 4-7 below illustrates the ECLiPSE system vision.[31]

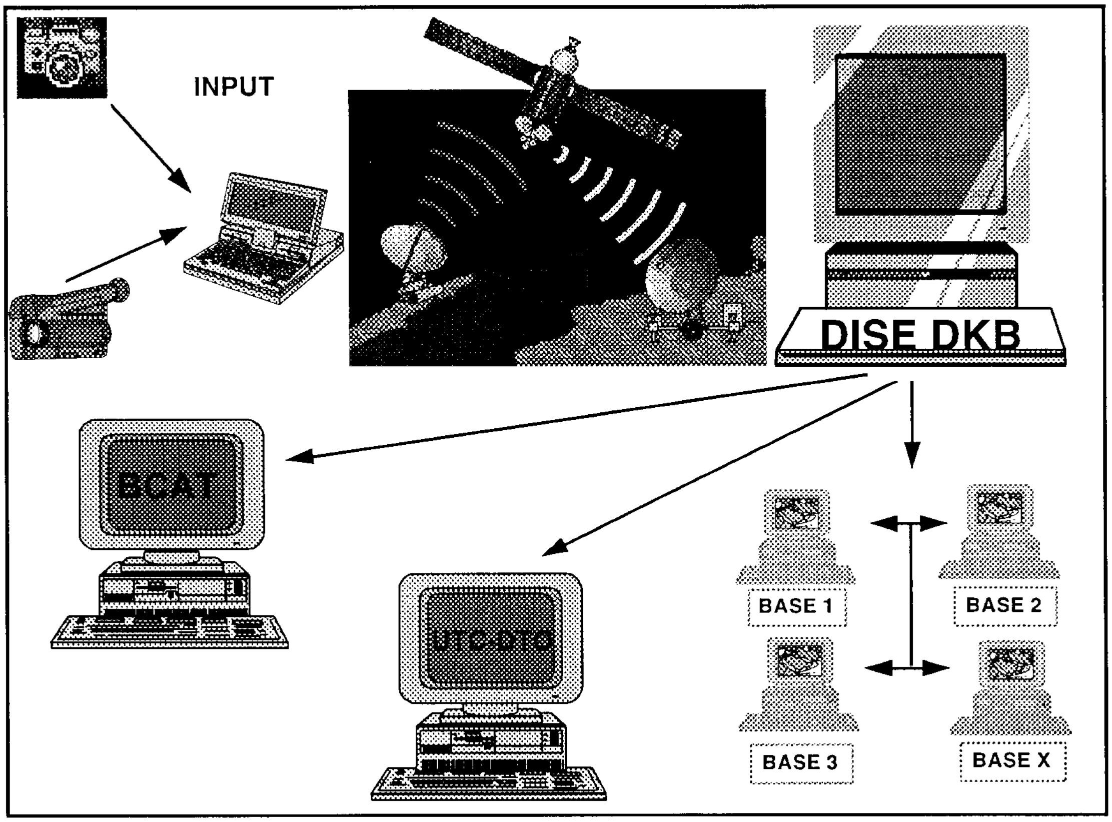

Figure 4-7. ECLiPSE Vision

Beddown Capability Assessment Tool (BCAT). The AF Logistics ECLiPSE system includes BCAT, which is designed to automatically develop or assess Base Support Plans (BSP) using beddown requirements, beddown location capabilities, and database comparison software.[32] The software is under contract development through Armstrong Laboratory with AF Logistics Management Agency (AFLMA) serving as the customer representative. Since the software is not available for review, personal interviews, briefings and Internet materials form the basis for these remarks.

AFLMA developed the BCAT vision from three separate MAJCOM requests for BSP automation and assessment. Assessing reception base capabilities was considered an

essential element of automating and evaluating BSPs, thus the application's name reflects the focus—Beddown Capability Assessment Tool. BCAT's reference documents for assessing base capabilities are the Civil Engineer planning guidelines (AFPAM 10-219).

There is a distinction between responsibilities for managing the BSP process and relying on functional expertise supporting the BSP process. As in BSP development, BSP assessment requires the same degree of close coordination between all supported and supporting forces. USAF's "train like we fight" doctrine ensures our peacetime roles and missions develop the functional expertise we mobilize for deployment planning and execution. That close coordination of functional experts achieves the synergistic BSP development and management process and avoids needless functional duplication. Although BCAT software was not available for ACEPES evaluation, apparent software overlap seems to necessitate greater coordination between the Logistics and Civil Engineer automation efforts.

Automated Airbase Contingency Estimator (AutoACE). AutoACE is a Microsoft Excel spreadsheet estimating and planning tool developed by the 49th and 2nd Civil Engineer Squadrons. AutoACE allows planners to assess the feasibility of force beddown plans and calculate actual requirements. It is based on planning factors found in AFPAM 10-219. The AutoACE program uses a series of spreadsheets with pull-down menus and macros. A sample image of an AutoACE spreadsheet is shown in Figure 4-8.

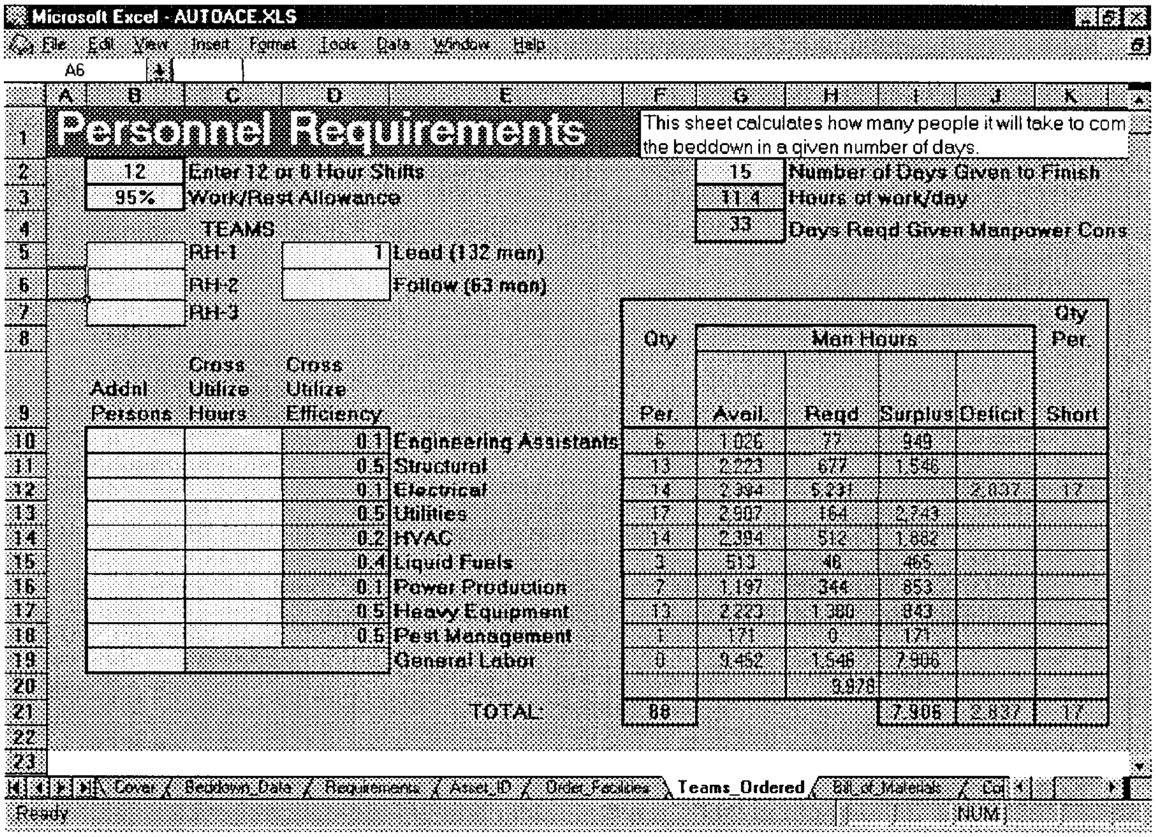

Figure 4-8. Sample AutoACE Spreadsheet

AutoACE calculations include requirements for facilities and utilities, engineer personnel, POL, runway and taxiways, ramp space, munitions storage, total number of aircraft by type, hangar space, squadron operations space, organizational maintenance space, general purpose maintenance space, and potable and unpotable water. In addition to these computations, AutoACE is dynamically linked to a prepared Microsoft Powerpoint presentation. This presentation can be used by the planner to brief the proposed beddown.[33]

Summary

From our findings, the first and second research subquestions have been answered through the identification of information databases and software applications. Appendix

D contains a summary of the hardware requirements and characteristics for each of the software applications evaluated. Some, such as CADD/GIS software, have the potential to form the nucleus of ACEPES while others provide ideas for new solutions. It is clear that much work has gone into automation technologies, and many organizations have realized the potential benefits automation has to offer. Additionally, several existing CE and COTS/GOTS products appear to have tremendous potential when combined with powerful database sources.

Notes

[1] "An Interview with Theodore Nanz, President, SPOT Image Corporation," *ESRI ARC News*, Fall 95, 40.

[2] Ohio State University, *Resolution, Satellite Imagery FAQ-3/5 Resolution*, Internet: http://www.cis.ohio-state.edu/h...magery-faq.part3/faq-doc-2.html, 21 March 1996.

[3] Ibid.

[4] Defense Logistics Agency, *New Mapping Agency Proposed, Defense Link News*, Available FTP: ftp://dtic.dla.mil/pub/deflink/bt621-95.txt, 6 January 1996.

[5] Ibid.

[6] Maj Diane Oswald, DMA/ACTF, eletronic mail to Maj Aaron Bridgewater, 14 February 1996.

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Chapter 5

Analysis

Overview

With the data and software applications presented in Chapter 4, we will now assess the best match between technology and the beddown process by answering the third and final research subquestion: *How can the best characteristics of existing systems and databases be integrated within a new system to improve the airbase planning and execution process?* In addition, we use research findings from the literature and expert counsel of the many people interviewed, to devise the overarching system requirements that ACEPES must possess. This comprehensive analysis sets the stage for final recommendations and conclusions presented in Chapter 6.

Data Analysis

The data obtained for this research was analyzed by considering the strengths and weaknesses of each of the automation tools and databases against the requirements of the original force beddown task list identified in the literature review, highlighted in Table 2-1, and presented again in Table 5-1. When analyzing the data and processes to be automated, the system's required functionality separated into two main categories. The first category is graphical requirements for mapping and site planning (CADD/GIS). The

second category focused more toward data-intensive requirements (DBMS). Category two requirements are best addressed with a tailored database management application where there is little concern or applicability to specific map-related locations. The complete ACEPES software solution is ultimately an application suite specifically developed and integrated to meet each process requirement with seamless transitions between tasks. Task transitions should be modeled after the data exchange ease of Microsoft's data interchangability between its Office products.

Mapping vs. Database Management. The distinction between mapping/site planning versus database management exists because traditional mapping software, for example CADD, usually stands alone or minimally interfaces with other database applications or larger decision support systems. Table 5-1 presents the research findings regarding CADD and/or DBMS requirements for each ACEPES task. Each task's automation requirement is evaluated with a High, Medium, or Low assessment of CADD and DBMS functionality.

The table reflects a key connection—most of the tasks requiring "High" mapping capability also require "High" database input or interaction. The higher the demand for CADD to quickly and accurately plan and adjust site planning, the higher the demand for database interaction for essential site layout constraints. Thus, mapping and database management requirements are complementary and the distinction merely highlights the need for both capabilities.

Table 5-1. ACEPES Functionality

SUB-PROCESS	TASK	CADD	DBMS
Pre-deployment	**Exercises**	H	H
	Training	L	H
	SORTS (Personnel, Equipment, Materials)	L	H
	OPLANS, CONPLANS, FUNCTIONAL Plans	L	M
Force Beddown	**Beddown Planning**		
	—Mission Analysis (force structure, ops level, threat, projected base population)	H	H
	—Host Nation Analysis (support/restrictions, climate, terrain, infrastructure, rainfall)	H	M
	—Site Analysis and Selection (existing facilities, ramp space, utilities, airfield conditions, arresting barriers, airfield lighting, NAVAIDs, topography, vegetation, soil types, theater areas of interest, airspace characteristics)	H	H
	—Site Requirements (calculation of needed utilities, tents, latrines, airfield systems)	H	H
	—Site Layout (aircraft parking, utilities, tents, mission support, security, clear zones, noise, air base defense, wind, topography, expansion)	H	H
	Execution		
	—Time-phased deployment of assets	L	H
	—Time-phased construction of base (prioritized tasks, construction schedules, resupply schedules, costs)	M	H
	—Resource management and security (personnel, equipment, materials, vehicles, facilities, infrastructure)	M	H
	—Environmental management	M	H
Sustainment	**Combat Support Operations**		
	—Operations and Maintenance of facilities and infrastructure	M	H
	—Resource Management and Security	M	M
	—Robust Supply Operations	M	H
	—Disaster Preparedness/Air Base Operability Planning	H	M
	—Explosive Ordnance Disposal	M	M
	—Firefighting and Rescue Operations	M	M
	—Environmental Management	M	H
	—Camp Support & Administration	H	H
	Recovery Operations—includes all of the above plus:		
	—Damage Assessment	H	H
	—Minimum Operating Surface Selection/Rapid Runway Repair	H	M
	—Expedient Repair of facilities and utilities	M	M
Redeployment	**Reconstitution of assets (disassembly, cleaning, packing, . . .)**	M	M
	Time-phased redeployment of assets (customs, TPFDD, . . .)	M	M
	Resource management and security	M	H
	Environmental Management	H	H

SUB-PROCESS	TASK	CADD	DBMS
	CADD—Computer Aided Design and Drafting DBMS—Database Management System H—High; M—Medium; L—Low		

In assessing several tasks with both "High" CADD and "High" DBMS requirements, the above table presents the case for a full-featured geographical information system, which is essentially a hybrid mapping/DBMS application. CADD has been the basis of discussion up to this point because most all Base Civil Engineer units use some form of CADD system, while GIS technology is relatively unfielded in the Civil Engineer career field. GIS not only provides mapping capabilities, but also integrates database (tabular) information with specific spatial (geographical/topological) data.[1]

ACEPES mapping software should follow CADD/GIS standards established by the DOD Tri-Service CADD/GIS Technology Center. Theoretically, any mapping (CADD/GIS) software purchased for contingency planning, engineer design and drafting, or even aircraft maintenance tracking, should follow the Tri-Service Spatial Data Standards (TSSDS). Those standards integrate into the DOD Data Dictionary standards and compliment the Federal Geographic Data Committee standards.[2] The TSSDS are available in an interactive, Microsoft Access–executable application.[3] Following the TSSDS will preclude another generation of individually-developed automation systems that cannot "speak the same language." We will now step through the four major ACEPES subprocesses exploring more distinctive aspects of CADD/GIS and DBMS automation requirements.

Predeployment. Exercise management and execution will rely heavily on ACEPES' GIS capabilities, while other readiness predeployment tasks will rely on DBMS applications. DBMS software will manage and report personnel training and equipment and material availability. An expert DBMS system would assist in Joint Operations Deliberate and Crisis Action Planning.

Force Beddown. Mission analysis at a MAJCOM headquarters will be one of the first steps of beddown planning when the USAF is called upon for deployment. MAJCOM-level mission analysis will confirm force structure basing feasibility with high resolution cartographic maps and multi-spectral imagery. GIS features required with this function should include automated aircraft parking plan generation. This feature should allow multiple aircraft types and recognize manual adjustments such as identification of parking ramp constraints such as fuel pit locations. Integrated into the GIS capability, ACEPES requires software interaction with any supporting databases such as existing host nation/U.S. Base Support Plans and DMA's Automated Air Facilities Information File.

Host nation regional analysis is another function that could yield critical information on available host nation support or restrictions, climate, current rainfall, terrain, supporting infrastructure and surrounding items of interest such as population and business centers. GIS mapping features will allow a "zoom out" function to view a regional perspective. The regional analysis can provide valuable insight for better estimation of transportation requirements.

A robust communications capability is required to quickly and confidently forward information compiled at the MAJCOM to the deploying unit. Although GCCS may

eventually provide all the communication capability required, MAJCOM CD-ROM recording hardware is a relatively low-cost, alternative that can guarantee "overnight" delivery of essential deployment planning information to the field units. If time and airlift allows, a wing advance team consisting of various unit logistics and beddown planners can greatly contribute to a successful beddown and time-phased force deployment list (TPFDL).[4]

Wing level site analysis and beddown planning begins when base engineers receive MAJCOM deployment information. Using combat air base performance planning principles, base engineers will use GIS software for conducting base comprehensive planning, allocating existing facilities, and siting expedient construction facilities.

Upon arrival at the deployment location, final site selection and site layout can begin only after wing logistics planners and base engineers confirm their planning information and assumptions. Planning confirmations and expedient surveys are highly desirable before seeking wing commander/host nation approvals. Initial surveys and approvals are also essential before beginning site layout and construction and time-critical in preparation for the bases earliest combat initial operating capability. GPS receiver–equipped civil engineer surveyors can accomplish precision surveying with fewer people and in less time than traditional surveying methods.[5] GIS technology provides direct GPS receiver communications permitting extremely fast and accurate site layout and infrastructure identification. Infrastructure identification could include surveying location and condition of existing facilities, ramp space, utilities, airfield conditions, arresting barriers, airfield lighting, NAVAIDs, topography, vegetation, soil types, environmental conditions, and airspace approach zone characteristics.[6]

Site layout, deployment and arrival of beddown assets, and initial base beddown activities are three key areas where ACEPES GIS and DBMS automation will drastically improve the beddown planning process. A deployed GIS would act as a decision support system for site layout based on automated planning factors and principles. As rapid changes are inevitable to a site plan, a GIS can quickly produce those changes for the many other wing units requiring base maps. Management of beddown assets and initial beddown activities can be a complex problem warranting a computer solution. Optimizing commander priorities with available personnel, equipment and materials is an engineer's top priority. Automation's speed, flexibility, and computer assisted decision support capabilities can amplify AF engineers' ability to meet their combat support mission.

Environmental management, resource management, and security are other beddown execution activities requiring high DBMS and medium-to-high GIS capability. GIS technology will also allow CE to better manage resource distribution and track dispersal locations of all CE resources. Accounting for beddown assets is often one of the most difficult tasks in contingency operations.

Sustainment. Sustainment activities mirror normal CE operations to some degree. In addition to continued construction and more normal base operations and maintenance, at some point ABO planning will increase. ACEPES should assist with database templates and decision support modules for disaster preparedness and base recovery planning. Many decisions such as dispersal locations and camouflage, concealment, and deception (CCD) may have been covered during site planning, but any sustainment period

should include refinements to the ABO plans. Both GIS and DBMS applications will assist in dispersal layout and management, protective construction and CCD analysis.

Engineers are tasked with base recovery. Whether the base is damaged by attack from air, Special Operations Forces, terrorist forces or natural disasters, engineers could use ACEPES to quickly collect damage assessment data with its GPS-to-GIS capability. Damage assessment teams (DATs) equipped with GPS receivers and laser designators can quickly and relatively safely pinpoint airfield and/or base damage or obstructions. Once DAT inputs are collected, a GIS module will calculate and plot minimum runway configurations necessary to allow aircraft operations. Any Rapid Runway Repair (RRR) and/or facility repair would use previously mentioned ACEPES features to optimize a prioritized task accomplishment list.

Redeployment. Redeployment is essentially the reverse of many of the same processes previously mentioned. In most instances, environmental management will emerge as a critical task before final departure and return of the air base to the host nation.

System Requirements

Interconnectivity

The same interconnectivity principle used throughout the wing must apply within the Civil Engineer Squadron and the Air Force CE community at large. Regardless of the time frame of the future wing-level environment, AF/CE should ensure ACEPES is incorporated vertically through all levels of command and horizontally through applicable functions of the CE mission. While this requirement might seem obvious, issues to

address include managing security constraints, robustness for peacetime and home-station contingency planning and transportability for deployment purposes. Maximizing ACEPES' base and MAJCOM interconnectivity will strengthen CE's mission beddown support through timely communication and efficiency among all players.

Peacetime Use

Peacetime Processes. A comprehensive contingency planning and execution system must address both the contingency processes themselves and the peacetime processes intended to build and sustain a readiness posture. Peacetime functions assigned to the CE readiness flight are an integral part of the readiness mission and reflect a near seamless transition into a contingency environment when a military crisis occurs.

Train Like We Fight. Air Force Doctrine describes the necessity of realistic training. The vast majority of peacetime USAF unit missions are training for combat missions. Air Force Manual 1-1 states, "Training has little value unless it is focused on the ultimate purpose of aerospace forces—to fight and win. . . . Aerospace forces must train as they plan to fight."[7] Upon incorporating peacetime Readiness Flight processes into ACEPES, the next requirement is to incorporate other day-to-day activities which mirror other contingency tasks. The true worth of an ACEPES automation tool will not be realized until the engineer uses the same site planning and drafting tools during contingency operations that he works with at his home station in peacetime.

Taken even further, synthesizing CE's key peacetime process of Facilities Management (FM) with the parallel contingency sustainment process could be a keystone ACEPES capability. Although this paper does not describe FM automation requirements, the process of siting, designing, constructing, resource management and air base mainte-

nance in peacetime and contingency are, in essence, identical. Of course expediency, duration, standards and resource availability may widely vary, but the actual processes and automated decision support systems are nearly identical. Consequently, ACEPES users, both engineering technicians and officers, could actually deploy with the same automation support they regularly used in their peacetime roles.[8] Conversely, using a different automation system only for deployments is a prescription for computer inefficiencies and debatable usefulness. A comprehensive, integrated ACEPES system, suitable for both peacetime and contingency use, would enhance experience and realism, two of the four training components discussed in AFM 1-1, and will prepare Civil Engineers for their combat support roles.[9]

Summary

An analysis of the various software tools and technologies, balanced against the beddown task requirements, shows that many tools and technologies already exist that can meet the requirements of ACEPES. General capabilities of CADD/GIS and DBMS programs were shown to apply, in varying degrees, across the beddown spectrum.

Specific software applications were evaluated to assess how well each could perform the individual beddown subtasks, and were evaluated on a scale ranging from "Fully meets requirement" to "Unsuitable for task." The analysis results are presented in Tables 5-2 and 5-3. Looking at a quick recap of the evaluation process, consider the three automation tools AutoACE, MGE, and ERDAS Imagine. Comparing these tools against the subtask Beddown Planning reveals that AutoACE received a "Fully meets require-

ment" rating in the Site Requirements category because the program fully calculates the core beddown planning activities contained within AFPAM 10-219.

Similarly, Intergraph MGE received a rating of "Meets requirement with customization" in the Site Layout category because the program has the ability to be customized and perform functions such as aircraft parking plan design. ERDAS Imagine received a rating of "Unsuitable for task" in the Robust Supply Operations category because it is an imagery viewing program and is ill suited for tracking and managing supplies.

The summary analysis reveals that different software applications have particular strengths and weakness for performing specific tasks. Some perform better than others consistently across the different subtask requirements. Others are distinctly advantages for certain tasks. Since this analysis is not a purely objective one and no software was actually tested, an overall rating that implies one product's competitive advantage is not provided. The analysis does however provide the research group with enough information to make sound automation strategy recommendations in the next chapter.

Table 5-2. Existing Software Applications

● Fully meets requirement ◉ Meets requirement with customization ○ Unsuitable for task	Intergraph MGE	AutoCAD IDE	Arc/INFO	ERDAS Imagine
Exercises	◉	◉	◉	○
Training	◉	◉	◉	○
Deliberate Planning	◉	◉	◉	○
Beddown Planning				
—Mission Analysis	○	○	○	○
—Host Nation Analysis	◉	◉	◉	◉
—Site Analysis and Selection	◉	◉	◉	◉
—Site Requirements	○	○	○	○
—Site Layout	◉	◉	◉	○
Execution				
—Time-phased deployment of assets	○	○	○	○
—Time-phased construction of base	●	●	○	○
—Resource management and security	●	●	◉	○
Combat Support Operations				
—Operations and Maintenance	●	●	◉	○
—Resource Management and Security	●	●	◉	○
—Robust Supply Operations				
—Disaster Preparedness/Air Base Operability Planning	●	●	●	○
—Explosive Ordnance Disposal—Firefighting and Rescue Operations	●	●	●	○
—Environmental Management	●	●	●	
—Camp Support & Administration	◉	◉	◉	○
Recovery Operations—includes all of the above plus:				
—Damage Assessment	◉	◉	◉	○
—Min Operating Surface Selection/Rapid Runway Repair	◉	◉	◉	○
—Expedient Repair of facilities and utilities				
Reconstitution of assets (disassembly, cleaning, packing, . . .)	●	●	○	○
Time-phased redeployment of assets (customs, TPFDD, . . .)	○	○	○	○
Resource management and security	●	●	◉	○

Table 5-3. Existing Software Applications (Continued)

● Fully meets requirement ◉ Meets requirement with customization ○ Unsuitable for task	EIS	CRISIS	REACT	AutoACE	JLEB	BCAT	Planmaster
Exercises	●	◉	●	○	○	○	○
Training	○	●	●	○	○	○	○
Deliberate Planning	○	●	●	○	◉	○	○
Beddown Planning							
—**Mission Analysis**	○	●	●	○	◉	○	○
—**Host Nation Analysis**	○	○	○	○	○	○	○
—**Site Analysis and Selection**	○	○	○	○	○	○	○
—**Site Requirements**	○	●	●	●	◉	●	●
—**Site Layout**	○	●	○	○	○	○	○
Execution							
—Time-phased deployment of assets	○	○	○	●	●	●	◉
—Time-phased construction of base	○	○	○	◉	○	○	●
—Resource management and security	○	○	○	○	○	○	◉
—Environmental management	○	○	○	○	○	○	○
Combat Support Operations							
—Operations and Maintenance	○	○	○	○	○	○	○
—Resource Management and Security	○	○	○	○	○	○	○
—Robust Supply Operations	○	○	○	○	○	○	○
—Disaster Preparedness/Air Base Operability Planning	●	○	○	○	○	○	○
—Explosive Ordnance Disposal—Firefighting and Rescue Operations	●	○	○	○	○	○	○
—Environmental Management	○	○	○	○	○	○	○
—Camp Support & Administration	○	○	○	○	○	○	○
Recovery Operations—includes all of the above plus:							
—Damage Assessment	◉	●	●	○	○	○	○
—Min Operating Surface Selection/Rapid Runway Repair	○	●	●	○	○	○	○
—Expedient Repair of facilities and utilities	○	○	○	○	○	○	○
Reconstitution of assets (disassembly, cleaning, packing, . . .)	○	○	○	◉	◉	○	◉

● Fully meets requirement ◉ Meets requirement with customization ○ Unsuitable for task	EIS	CRISIS	REACT	AutoACE	JLEB	BCAT	Planmaster
Time-phased redeployment of assets (customs, TPFDD, . . .)	○	○	○	◉	●	◉	●
Resource management and security	○	○	○	○	◉	○	◉

Notes

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Chapter 6

Recommendations and Conclusion

Overview

This chapter provides the research recommendations and conclusions. There are both short- and long-term strategies that the CE community can undertake to construct useful automated tools for the air base planning process. Our recommendations follow.

Short-Term Recommendations

Automation technology holds vast potential to improve the mission effectiveness and efficiency of the CE beddown planning and execution process. There are a variety of software programs and data sources that, if harnessed, would revolutionize the way Civil Engineers currently operate. However, successful implementation of ACEPES will require a good solid design, appropriate software and hardware selection, database development and maintenance, and successful integration and mission enhancement of all components. Specifically, we recommend the following short-term implementation strategy:

1. Use a PC-based system compatible with existing equipment
2. Use GIS as the core software program
3. Use COTS/GOTS software where possible
4. Use custom programming
5. Create an AF/CE clearinghouse for all CE beddown planning tools

ACEPES design should be fully compatible with automation technology already in place or proposed for the MAJCOMs and Civil Engineer squadrons. This requirement would allow ACEPES to complement work already underway rather than become a standalone module to be used only in deployments and contingency scenarios. A system design with the same look and feel as computer products currently in use will lessen software training requirements, extend user proficiency, and increase process inefficiencies.

CE is currently undergoing an Air Force automation upgrade. This upgrade will result in a PC-based local area network (LAN) at each MAJCOM and squadron. The Microsoft DOS/Windows 3.1 operating system now in use will eventually be replaced by Windows 95.[1] Therefore, it is important that ACEPES be able to operate seamlessly in this environment.

Software

The use of COTS/GOTS software within ACEPES will reduce application development, procurement and maintenance costs. However, there are at least two major transitional steps that must occur before an organization can realize any COTS/GOTS benefits—software customization and the building of a GIS database.

The first transition from COTS/GOTS software purchase to implementation requires some degree of software customization. Depending upon the complexity of the process(es) and related software, customization can be a long-term effort in itself.

Although customization may cost time and money, it is still much more cost effective than the sole-source development alternative. For example, loading a new spreadsheet program provides a powerful tool for numerical analysis. Yet, until the spreadsheet's format and equations are customized for your particular needs, the capability is untapped.

Customization and integration of COTS/GOTS software is critical since there is not a single application that meets the total needs of the CE community for planning and executing beddown operations. What presently exists are a number of programs that can accomplish portions of the ACEPES vision. For example, programs such as CRISIS, AutoACE and Planmaster can all generate beddown planning information. However, each is a standalone application with a narrow mission focus and with little or no interconnectivity. In short, the CE community has access to a number of automation tools but lacks an integrated tool kit.

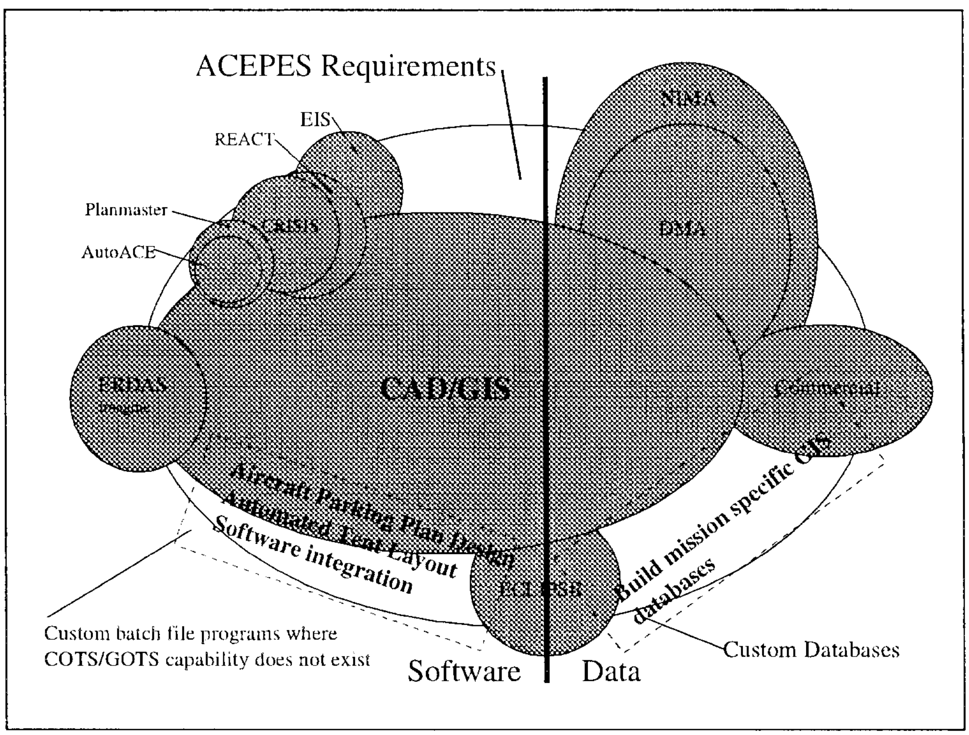

Figure 6-1. Applications, Data Sources and ACEPES Requirements

To help illustrate this point, Figure 6-1 conceptually shows how existing software programs meet portions of total ACEPES requirements and the need for software/ database customization. The total ACEPES automation requirement is shown on the large unshaded oval in the back of the figure. The smaller shaded ovals and circles overlaying the large oval depict how a particular application provides coverage for that requirement. Areas where there is no shading indicates where customized applications need to be developed and databases built.

Figure 6-1 portrays GIS as the core of ACEPES requirements. Our immediate to short-term recommendation is therefore to utilize a GIS platform while integrating contingency planning programs into the system. From a pure capabilities standpoint, GIS programs have the greatest potential in fulfilling the Civil Engineer planning and execution automation requirements. Intergraph, AutoCAD, and Arc/INFO are highly capable programs and can incorporate user designed macros (batch files) needed to automate specific mission needs such as aircraft parking plan designs. These custom-designed macros are critical elements in fully implementing ACEPES.

As for a specific GIS, we recommend Intergraph or AutoCAD. We are recommending one of these two GIS programs because they are CADD-based and most CE squadrons are currently using the CADD segments of these GIS systems. The fact that these products are currently in use at most bases allows CE to capitalize on the existing program knowledge base and training. Also, it makes sense to use the same tools in a contingency as are used in peacetime. If a Civil Engineer squadron has not converted to a CADD system we recommend Intergraph MGE since it has greater capability than both AutoCAD and Arc/INFO (see Appendix E).

Intergraph and AutoCAD are both capable of processing raster image data and incorporating it into a GIS. The current image requirements for ACEPES are not expected to require the procurement of specialized satellite imagery programs such as ERDAS Imagine. However, should satellite imagery analysis requirements expand and become more sophisticated, ERDAS Imagine should be considered. ERDAS Imagine like many other sophisticated imagery viewing programs, has greater requirements in terms of processor speed and RAM. ACSC runs ERDAS Imagine on a Sun workstation with 96 megabytes of RAM—significantly more sophisticated than the system envisioned for ACEPES.

An example of a customization and integration application is the Contingency Planner concept program under development by Science Applications International Corporation—SAIC. Contingency Planner is a concept demonstration program proposed for use as a decision support tool for contingency planning and execution.[2] The Contingency Planner demonstrates an integrating concept for managing and communicating a deployment scenario, mapping and GIS support, and database management supporting all phases of the ACEPES contingency process. Contingency Planner's integration capability is envisioned to maximize available COTS/GOTS and fill gaps between off-the-shelf software and requirements while functioning as an expert system/decision support shell for the entire process.[3]

Other possibilities could incorporate this application into peacetime CE business practices. COTS/GOTS Automated Mapping/Facilities Management (AM/FM) software could be a module interfaced through a peacetime/contingency variant of the Contingency Planner. Since Contingency Planner is only a concept demonstration, actual evaluation is

not possible. The sample demonstration screen, shown in Figure 6-2 below, reflects the intent to design a user-friendly, "point and click" environment providing ready access with minimal training.

Figure 6-2. Contingency Planning Demo

Databases

Particularly in the near term, the CE community must build and maintain much of its own databases since existing data sources are fragmented or not at the detail required for contingency planning. Our recommendation is that the building of these databases be integrated and combined with the software customization effort. Customization and

building the databases will be the most expensive and long-lived component of ACEPES.[4]

Although much of the data needed for ACEPES can be obtained from DMA, it is not available in a consolidated library. DMA is making strides to consolidate its many digital data sources into a library that can be accessed but that is some years away. Until then, required information can be obtained by request. To prevent duplication of effort, MAJCOMs should serve as the focal points for DMA requests. MAJCOMS need to build databases for locations that are possible deployment areas using all available information sources including units returning from deployed sites.

Hardware

The computer hardware for ACEPES is a critical component in the automation process and is driven by the operating parameters of the software. ACEPES hardware must be adequately sized to accommodate software applications, be deployable, and be capable of handling classified information.

Again, the software driving hardware capabilities will be GIS. GIS vendors recommend a Pentium-based computer, no less than 32 megabytes of Random Access Memory (RAM) and a SVGA monitor. Hard drive memory requirements for the operating system, program files, and help files are expected to be in the 200 to 300 megabyte range. GIS data requires a large memory capacity ranging between one to seven gigabytes depending on the user's particular application. While this large memory can be provided at a PC workstation, laptop computers are limited to around 1.6 gigabytes. Therefore, portable systems may require an external hard drive to augment hard drive memory. Other peripheries required for ACEPES include a high-speed CD-ROM, fax/modem, and output

devices such as digital plotters and laser printers. A reasonable estimate of what the ACEPES hardware might look like for the MAJCOM and base are shown in Table 6-1 and Table 6-2.

A MAJCOM system is expected to be more robust since they will be concerned with deployment of more than one unit, analysis of multiple locations, site selection and the analysis of satellite imagery. To ensure proper integration of software and hardware, the actual system design should be accomplished by a consulting firm with expertise in GIS, imagery systems and the latest computer technology.

Security requirements must also be addressed in the development and fielding of ACEPES. Accessing satellite imagery through systems such as GCCS, WCCS, and SPIRNet will require a machine with the proper security protocols. However, most of the planning activities we envision for ACEPES will be unclassified. For this reason, items such as removable hard drives would be highly beneficial and would allow the same machine to be used for either unclassified or classified planning.

Table 6-1. MAJCOM ACEPES Hardware

ACEPES Item	Features
Computer	• PC Workstation Pentium Processor 32–64 MB RAM 5–7 Gigabyte disk storage CD-ROM (Write capable) 28.8 Fax/Modem 21 inch SVGA monitor • Laptop Computer Pentium Processor 32 MB RAM 1.6 Gigabyte disk storage 1–2 Gigabyte external drive CD-ROM 28.8 Fax/Modem SVGA monitor
Software	Windows NT/95 Intergraph MGE Oracle DBMS Microsoft Office
Peripherals	High speed plotter laser printer flatbed scanner

Table 6-2. Base ACEPES Requirements

ACEPES Item	Features
Computer	• PC Workstation Pentium Processor 32–64 MB RAM 2–3 Gigabyte disk storage CD-ROM (Write capable) 28.8 Fax/Modem 21 inch SVGA monitor • Laptop Computer Pentium Processor 32 MB RAM 1.6 Gigabyte disk storage 1–2 Gigabyte external drive CD-ROM 28.8 Fax/Modem SVGA monitor
Software	Windows 95 Intergraph MGE Oracle DBMS Microsoft Office
Peripherals	High speed plotter laser printer flatbed scanner

Automation Clearinghouse

While performing this research, it became very clear that many civil engineers have attempted to automate beddown planning functions. These projects run the range from contractor-developed software to Air Force members writing their own programs. In fact, AutoACE was developed by a two junior AF officers as a "back room project." This program is very effective for what it was designed to do: apply planning factors and engineering estimates to calculate the types and quantities of deployable assets in support of a contingency.

The problem is, few people know about AutoACE because it was designed at Holloman and it resides at Holloman. There is no central CE clearinghouse to collect such products, evaluate them, and crossfeed the best ones across the CE community.

Therefore, it is recommended that such a clearinghouse be established to capture the many independent automation initiatives being pursued. Furthermore, there is logic to assign this duty to the Silver Flag Training Site, under the ASG's oversight. Silver Flag is charged with bi-annual combat training and the best automation products could be incorporated into their training program.

The choice of Silver Flag is also beneficial as the school cadre is composed of experienced RED HORSE engineers who are experts in beddown planning and execution. This expertise would provide the practical evaluation of automation products necessary when fielding capable, user-friendly systems. Finally, Silver Flag is collocated with HQ AFCESA, who is charged with CE's technical development. This proximity would provide synergies in automation evaluations and crossfeeds to field units.

Long-Term Recommendations

ACEPES long-term recommendations build upon the short-term implementation by leveraging the core CADD/GIS system and essential database management and C4I programs. No matter how future DOD automation systems are configured, the core of ACEPES will remain the GIS. Long-term impacts on the proposed ACEPES architecture would only involve full integration of automated beddown processes into a seamless software suite in addition to engineering interfaces to allow full interoperability within future DOD C4I systems.

Because overarching automation platforms, GCCS and WCCS, are still being developed, our ability to reach specific long-term recommendations for ACEPES were limited. To ensure CE automation efforts fully integrate with these overarching systems, strong links must be maintained with GCCS and WCCS development agencies. HQ USAF/CE Automation Steering Group is networked with these offices and has provided the necessary guidance to guarantee CE automation reaches a fully interoperable end state.[5] The results of our research, collectively known as ACEPES, propose details for the contingency planning and execution portion of the ASG roadmap.

The Integrated Process Approach

The AF/CE Automation Strategic Plan envisions the future Automated Civil Engineer System (ACES) as a comprehensive system integrating each of the eight CE functional flight responsibilities. The vision of ACES readiness and contingency automation includes a common peacetime/contingency system that is "portable and deployable to ensure personnel will not have to learn new software applications for contingency operations."[6] ACEPES is envisioned as the deployment module that would function independently in contingencies, yet operate at home station with seamless interfaces to peacetime-only modules.

Accepting peacetime/contingency functionality, long-term ACEPES development cannot be segmented from the rest of ACES. For example, CADD/GIS "ownership" is usually assigned to the Engineering Flight, since CADD's historical strength and focus has been engineering design and drafting functions. CADD/GIS software application is a prime example where today's information technology can readily provide base facility and infrastructure information across the CE organization.

In peacetime, Operations and Maintenance (O&M) personnel can use a networked CADD/GIS system to quickly reference and update facility equipment data shared with the Engineering Flight. As either in-house O&M shops or Engineering contract projects modify facilities, a shared facility database provides everyone interested with the updated information, thus greatly enhancing CE productivity and effectiveness.

In its contingency role, an earlier example bears repeating. The Engineering Flight engineers and draftsman will work for the Prime BEEF commander for deployment taskings. When called upon for beddown site planning, the engineer's design tools and the draftman's automated drawing tools should be the same CADD/GIS system used in peacetime. The ACEPES prospect for dual-roled peacetime and contingency CADD/GIS capabilities exemplifies the benefits offered by other dual-roled automation features. The following diagram depicts a broad perspective of where ACEPES contingency tasks overlap with several CE functional flight responsibilities. The illustration points out the variety of CE flight participants necessary to develop an integrated ACEPES "readiness" module which includes a contingency planning and execution system.

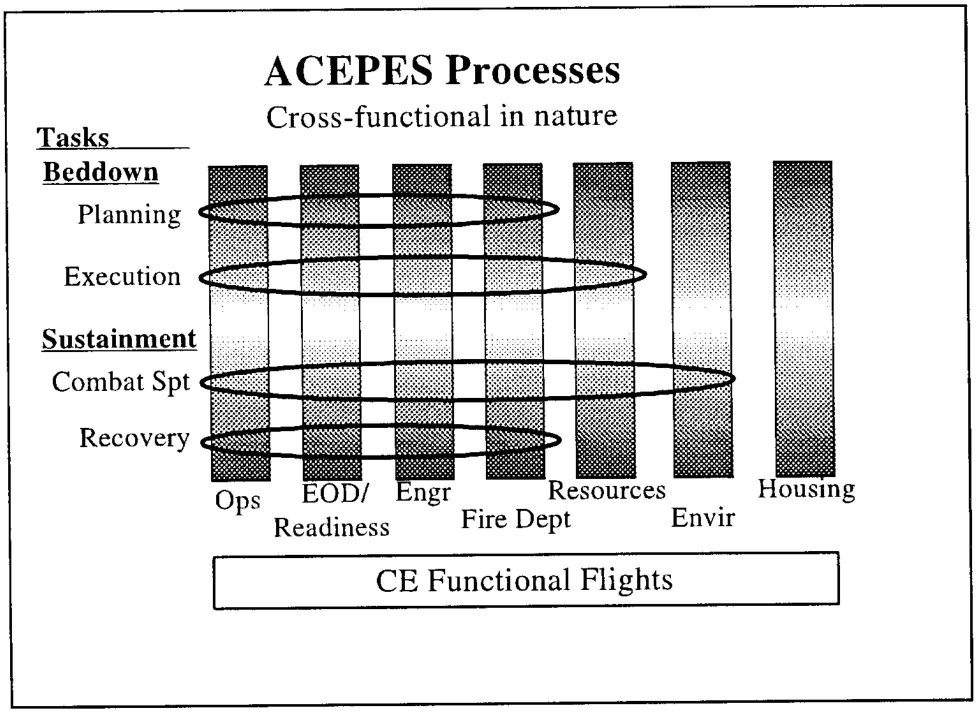

Figure 6-3. ACEPES Cross-functional Processes

The AF/CE ASG meets periodically to provide continuing energy and direction toward development of the next generation information management system—the ACES. The lead command appointed by the ASG to automate CE readiness functions is Air Combat Command. The ASG recently chartered a Readiness/EOD Integrated Process Team (IPT) to enhance CE by leveraging available information technology.[7] The IPT approach is endorsed by the Deputy Assistant Secretary of Defense (Installations) within the Installation Corporate Information Management (ICIM) program.[8] The Readiness/ EOD IPT goals are as follows:

1. Provide modern, interoperable decision making support tools responsive to CE readiness needs.
2. Provide a clear, accurate, and current picture of CES readiness resource status.
3. Provide automation tools that support contingency and normal operations and expedite the transition between them.
4. Make existing staffing more productive.
5. Streamline and improve readiness processes:

6. Discipline taskings and information needs.
   a. Ensure focus on contingency response responsibilities.
   b. Ensure right mix of skills.
   c. Ensure process sharing and exchange with and within other units.[9]

The IPT's approach will frame the Readiness/EOD processes within the backdrop of the latest information and automation technology. Thus, the IPT will not simply update the current computer system, but will seek to "reengineer" processes by applying new solutions enabled with new technology to conceive a new automation system.[10]

Our research effort laid the groundwork for organizations working automation issues such as our sponsor, HQ AMC, and the Readiness/EOD IPT. We believe this research provides helpful background, analysis, and recommendations for automating contingency beddown planning and execution.

Recommendations for Additional Research

In this research report, we have touched only on the ACEPES vision by providing realistic short- and long-term recommendations for a system concept. There is much work left to accomplish. We anticipate that HQ AMC will develop a sound Statement of Work for the development of a short-term automation tool using available GIS and DBMS software applications, customized integration macros, and available information databases. While this development takes place, there still remain many areas of further research for short-term automation products. Some existing technologies that show considerable promise include interactive video, resource optimization models, digital camera imaging, electronic clipboards, bar coding, chemical/biological agent sensors, laser designators for BDA, pen-based electronic clipboards, and GPS enhancements.

Additional study is needed to show how these technologies can be specifically incorporated into an automated beddown planning system.

Looking ahead, there are many areas of long-term follow-on research interest that can and should be pursued concurrently with short-term automation tool development. First, the CE community needs to develop doctrine for its automation strategies. It will be the only way we can improve upon mistakes of the past. Second, the concept for a long-term ACEPES system design should be advanced, incorporating all CE peacetime and contingency requirements in accordance with the ASG. Third, the concept of constructing a universal DOD database containing requirements-based information should be investigated. As we have shown, the power of automation is heavily dependent on system input.

Finally, the potentially significant advantages that new technologies bring to a long-term automated planning tool is a tremendously worthwhile endeavor for future study. This could include advanced unmanned aerial vehicle data gathering and assessment applications, sensored or "smart" buildings relaying critical information, virtual reality training applications, full system connectivity with C4I infrastructure, and automation doctrinal development. These suggested areas of further research are just a few ideas that would make excellent projects for future students.

Conclusion

This research project describes a logical trail of system requirements that gives the MAJCOM Civil Engineer a starting point in automating the beddown process. Our experience, contacts with professionals, and lessons learned from actual deployments and

literature searches confirmed the genesis of our research: automation is indeed a worthwhile goal—resulting in faster, more flexible, more consistent, and more accurate methods of air base planning and execution.

Considerable time was spent defining the functional tasks that a civil engineer completes during the beddown process. These functional tasks were shown to be reliant on a myriad of planning factors and command priorities which drove specific requirements. Having defined the requirements, we were able to identify the automation technology (mapping or database management) best suited for the requirement. A complete review of available information databases, software applications, and current and future AF/CE automation initiatives provided the insight for specific short- and long-term strategy recommendations.

Through qualitative analysis, we determined that there have been many individual attempts to automate portions of CE beddown processes. However, none of these products provided the full range of capabilities that the CE beddown planner requires. Furthermore, because there has been no clear mandate to integrate these separate efforts or develop a comprehensive planning toolbox for CE, inefficient manual processes continue as the status quo. Automation products that answer a portion of the requirement (such as AutoACE) have remained the domain of moonlighting CE enthusiasts.

Many tools do exist that could be integrated into a short-term solution. Our research showed that the driving factor for automated beddown planning is mapping capability. As such, we recommended that CE employ a GIS as the core of ACEPES. While many CE squadrons have GIS and CADD systems in their Engineering Flight, those who do not are encouraged to invest in the Intergraph MGE system; it is viewed by our research team

as the most versatile and powerful GIS available. Additionally, specialized COTS/GOTS software exists that can be employed by the engineer to perform such mechanical, time-consuming tasks as calculating beddown assets, prioritizing work requirements, and managing manpower and resources (Tables 5-2 and 5-3). Although these products are not integrated into a software suite, they still provide a viable alternative to slow, inflexible manual processes. Where COTS/GOTS products do not exist, for example automated aircraft parking plans, specialized functions can be automated through custom programming.

The long-term solution to CE automation lies with the HQ USAF/CE Automated Steering Group and their close ties with DOD C4I automation intiatives like GCCS and WCCS. While striving to field a comprehensive, fully-integrated CE automation suite (to include beddown functions), care must be taken to ensure that its architecture seamlessly operates within the umbrella DOD systems of the future. As these systems are still under development, we were unable to recommend specific system features of a long-term ACEPES platform. However, the ASG has published a roadmap to guide MAJCOM automation efforts and continues to provide the rudder necessary to ensure CE remains on course to full interoperability with the C4I systems of the future.

Notes

[1] Civil Engineer Automation Steering Group, *Air Force Civil Engineer Automation Strategic Plan,* 20 September 1995, 2.

[2] Daniel J. Barker, "Civil Engineer Contingency Support Plan" (Paper presenting Software Demonstration, 21 February 1996), 1.

[3] Daniel J. Barker, SAIC, telephone interview by Maj Mike Hutchison, 28 March 1996.

Notes

[4] Environmental Systems Research Institute, Inc., *Geographic Information System Solutions for Defense, ESRI White Paper Series*, August 1995.

[5] Civil Engineer Automation Steering Group, *Air Force Civil Engineer Automation Strategic Plan,* 20 September 1995, i.

[6] Ibid., 2.

[7] HQ AFCESA, "Update on the Functional Process Improvement Program," *A-Gram 95-13 (draft)*, 20 March 1996.

[8] OASD (Installations) *Installations CIM Home Page*, Internet: http://www.acq.osd.mil/inst/icim.html, 3 April 1996.

[9] HQ USAF/CE, *AF/CE Readiness Flight Automation IPT Charter,* March 1996.

[10] Mike Bascetta, "Software Development Process," briefing, AF/CE Automation Steering Group, Tinker AFB, Ok., 29 June 1995.

Appendix A

Points of Contact

Military and Government

ORGANIZATION	NAME	PHONE #
HQ AMC/CE	BGen Phil Stowell	DSN 576-3125
HQ AMC/CEO	Lt Col Dave DeFoliart	DSN 576-3143
HQ AMC/CEOO	Lt Col Alberto Armesto	DSN 576-4008
HQ AMC/CEOX	Mr. Bob Fox	DSN 576-3950
HQ AMC/CEPR	Capt Gerry Castelli	DSN 576-3016
HQ AMC/CEOX	CMSgt Mike Doris	DSN 576-3950
HQ USAF/CEOO	Mr. Bob Clearwater	DSN 225-7774
HQ ACC/CEO	Mr. Paul Parker	DSN 574-3024
HQ ACC/ESX	Maj Chris Bagnatti	DSN 574-5335
HQ PACAF/CECS	Capt Dan Costello	DSN 449-5291
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HQ AFCESA/CC	Col Pete Kloeber	DSN 523-6101
HQ AFCESA/CEO	Lt Col Steve Waller	DSN 523-6373
HQ AFCESA/CEOA	Lt Col Dave Gaitros	DSN 523-6455
HQ AFCESA/CEOA	Maj Dennis Anderson	DSN 523-6209
HQ AFCESA/CEXR	Maj Mike Carson	DSN 523-6306
HQ AFCESA/CEOM	Maj Pat Ryan	DSN 523-6363
HQ AFCESA/CEOM	Mr. Mike Bascetta	DSN 523-6389
HQ AFCESA/CEOA	Maj. Roger Weaver	DSN 523-6409
HQ AFCESA/HO	Dr. Ronald Hartzer	DSN 523-6264
HQ AFCESA/CEXX	TSgt Steve Reed	DSN 523-6160
HQ AFSPC/CEP	Col Gene Best	DSN 692-3192

WL/FIVCS-OL (Air Base Sys Br)	Dr. Jonathon Duke Mr. Gregg Hill	DSN 523-3755 DSN 523-3755
HQ AFLMA/LGX (ECLiPSE)	Capt Carmine Vilardi	DSN 596-3535
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US Special Forces Command (Rapid Map Production Facility)	Mr. Roger Ryan	DSN 968-3123
49 CES/CEOO (AutoACE)	Lt Eric Swenson	DSN 867-5104
WCCS POC @ Hanscom	Mr. Murray Daniels	DSN487-5165
DMA/ATCF DMA Customer Desk DMA (DIA Liaison)	Maj Diane Oswald Mr. Mike Thomas Ms. Sandra Weber	(703) 275-8610 DSN 287-3495 (703) 907-0742
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AFCEE/DG	Mr. Gary Honeycutt	DSN 240-4238
USAE-WES	Mr. Ed Regalman	(601) 634-4604
Geo Dynamics	Mr. Allan Sexton	(205) 277-2177

Commercial POCs

ORGANIZATION	NAME	PHONE #
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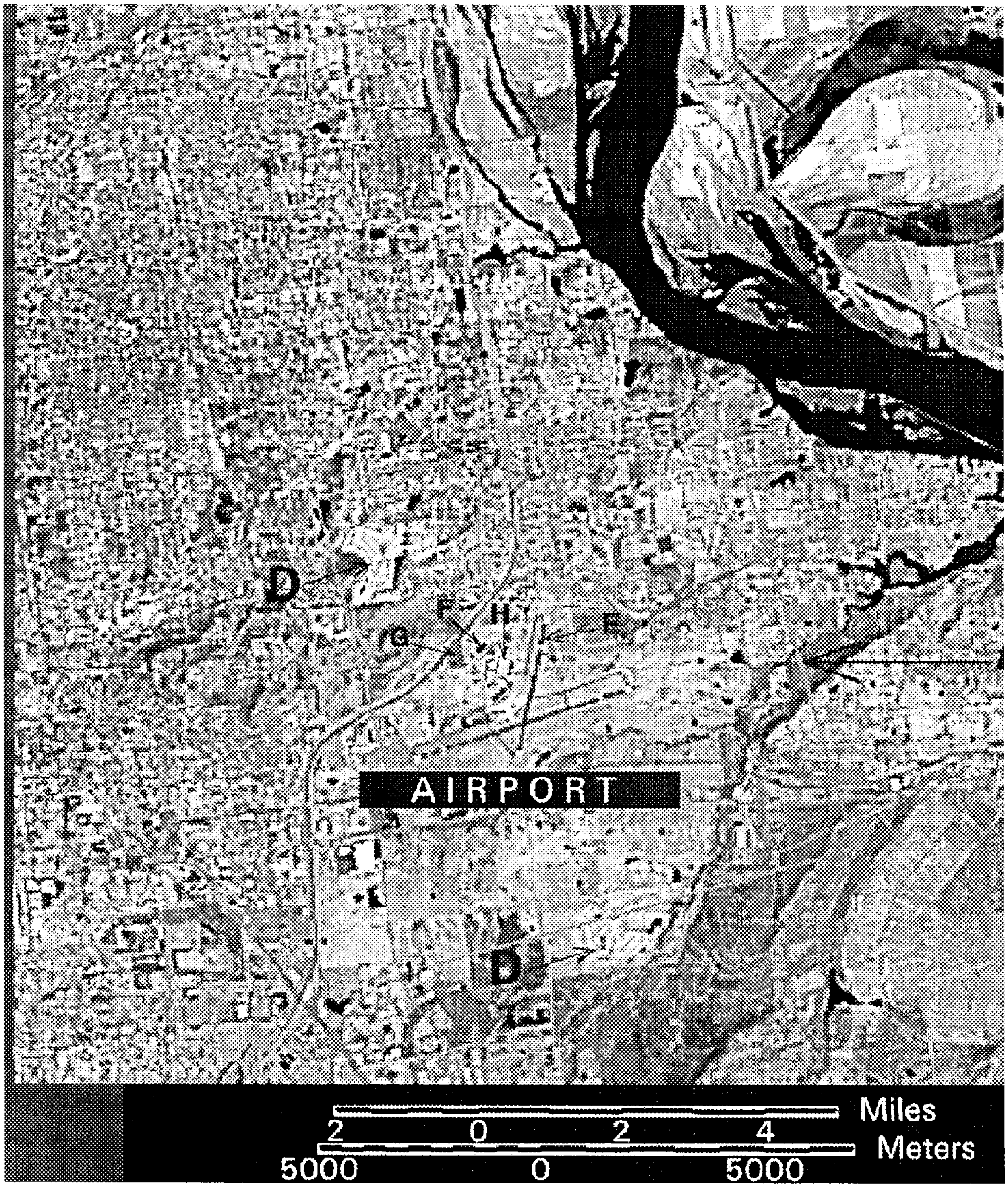
ESRI, Inc. (Bullock-Tice Assoc Architects)	Mr. Matt Davis Mr. Peter Slatcoff	(508) 777-4543 (904) 434-5444
EIS International, Inc.	Ms. Marge Gold	(301) 738-6900

ERDAS, Inc.	Mr. Kurt Schwoppe	(703) 354-7415
	Mr. Fred Woods	(703) 354-7415
Decision Dynamics, Inc.	Mr. Louis Alfeld	(301) 565-4040
	Mr. Robert Sholtes	(301) 565-4040
Intergraph Corp (Mapping & Infr)	Mr. Mike Barker	(205) 737-1972
Intergraph Corp.	Mr. Dan Weston	(205) 730-7320
	Mr. Randy Hunt	(800) 747-2232

Appendix B

Satellite Imagery

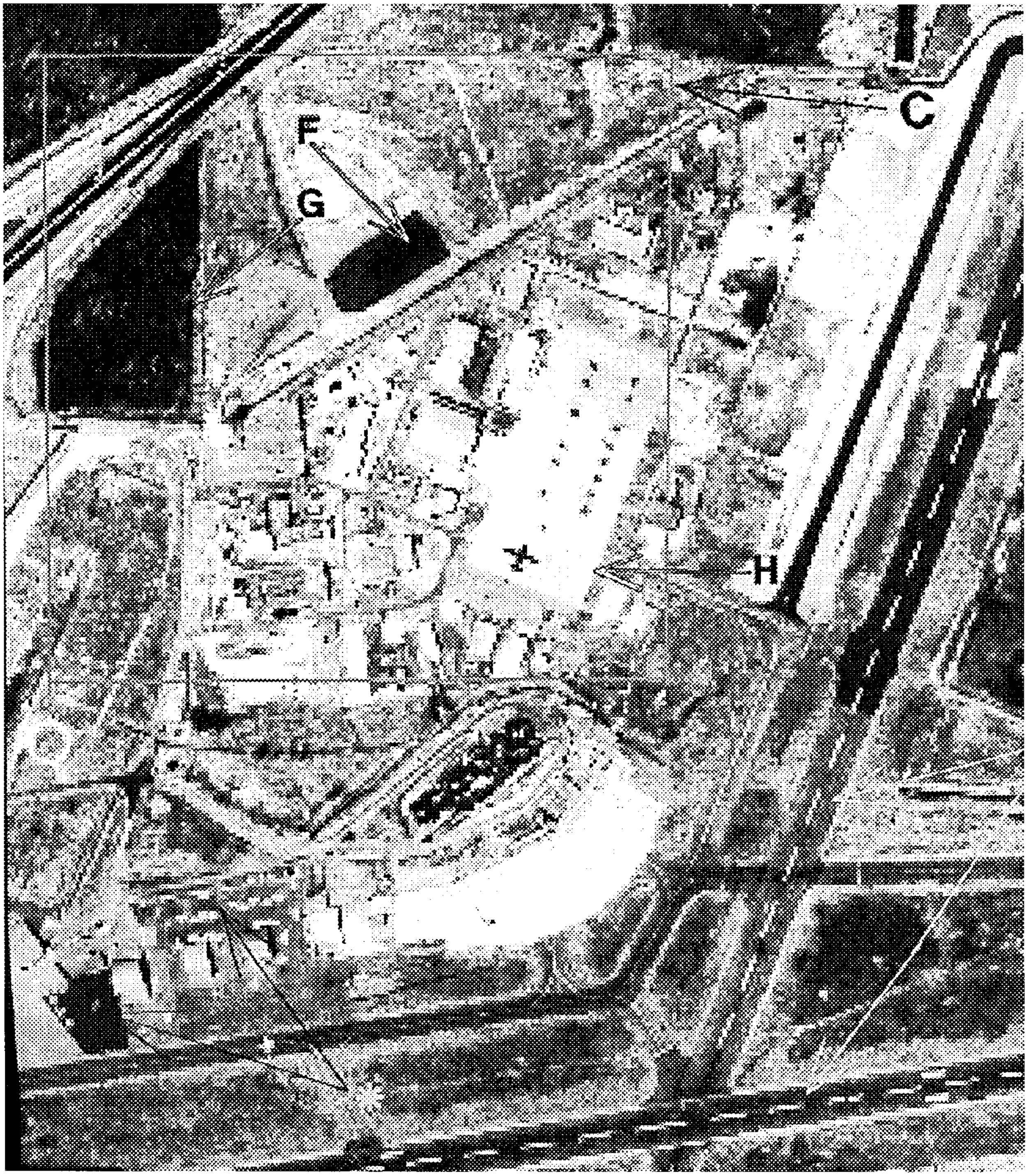


Caption from scanned photo: "This represents the best resolution available from Landsat without "blurring or pixeling out."

Figure B-1. 30-meter resolution provided by Landsat 5 Thematic Mapper

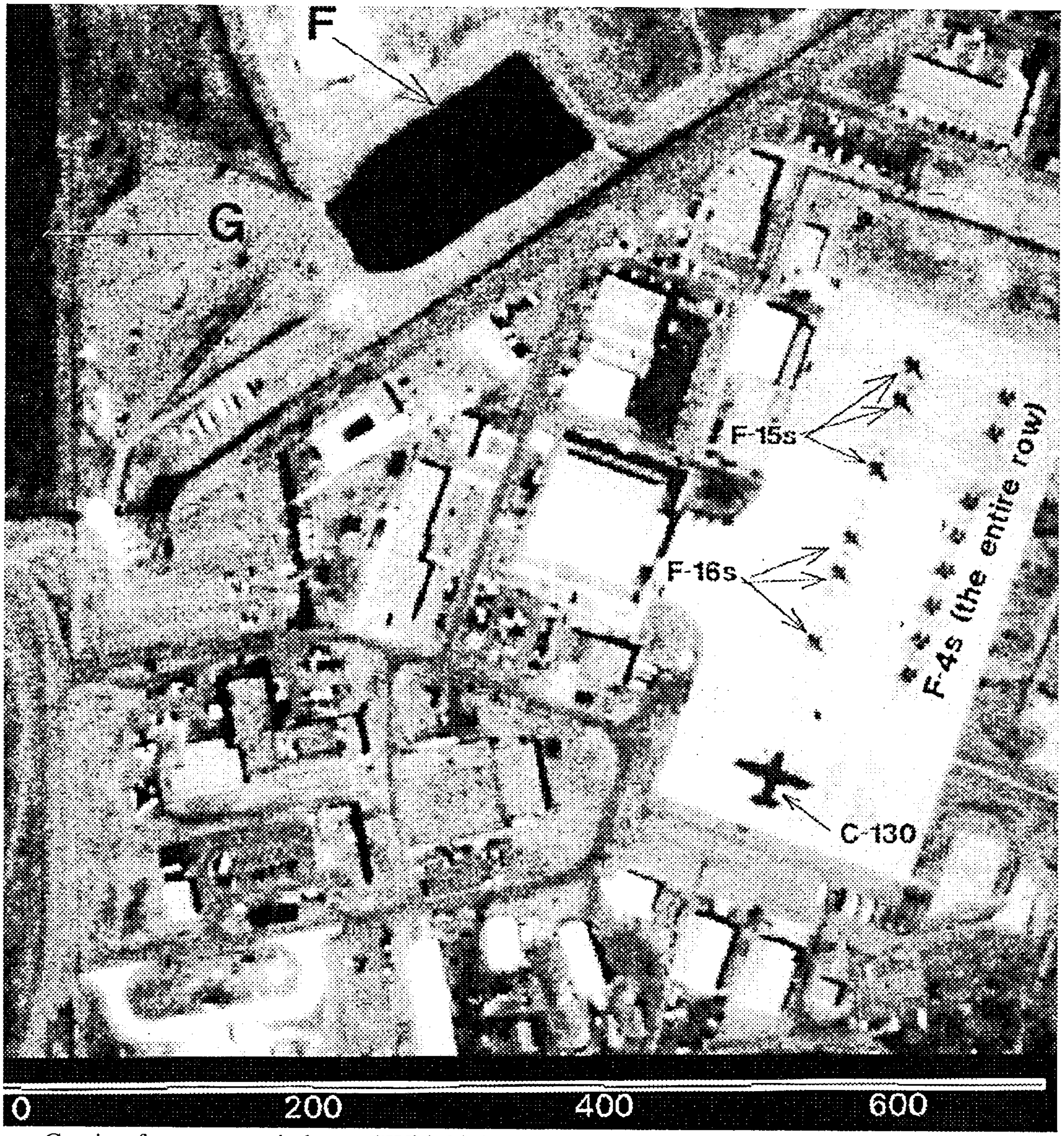
Caption from scanned photo: "This represents the best resolution available from SPOT without 'blurring or pixeling out'."

Figure B-2. 10-meter resolution provided by SPOT Panchromatic imager



Caption from scanned photo: "This simulated Landsat 7/HRMSI image was created by merging Landsat 5 (TM bands 7, 4, 2) with U-2 photography. It accurately represents the best resolution available from a Landsat 7/HRMSI system-merged image. Landsat 7/HRMSI has a launch date in 1997."

Figure B-3. 5-meter resolution from Simulated Landsat 7/HRMSI merged imagery



Caption from scanned photo: "With high resolution black and white imagery sources, the sun angle can obscure identification features such as dirt roads/airstrips and some water/land features."

Figure B-4. Digitized U-2 Photography resampled to 1.5 meter resolution from the National High-Altitude Photography Program (NHAP)

Appendix C

Software Requirements

Name	Function	Operating System	Processor	RAM	Disk Memory	Laptop
Intergraph MGE	CADD/ GIS	Windows 95 Windows NT UNIX	Pentium	32–64 MB	20–30 MB	Yes
AutoCAD ADE	CADD/ GIS	Windows 95 Windows NT UNIX	Pentium	32–64 MB	20–30 MB	Yes
ARC/INFO ArcView	GIS	Windows 95 Windows NT UNIX	Pentium	32–64 MB	20–30 MB	Yes
CRISIS	GIS Der	Windows 95	Pentium	8 MB	10–20 MB	Yes
REACT	GIS Der	Windows 95	Pentium	8 MB	10–20 MB	Yes
EIS	GIS Der	Windows 95	Pentium	8 MB	10–20 MB	Yes
ERDAS Imagine	GIS Der	Windows 95 Windows NT	Pentium	96 MB	20–30 MB	Runs very slow
Planmaster	BareBase Planning	Windows 95	Pentium	8 MB	10–20 MB	Yes
ECLiPSE/ BCAT	Database Mgt	Windows 95 UNIX	Pentium	8 MB	10–20 MB	Yes
AutoACE	BareBase Planning	Windows 95	Pentium	8 MB	1–2 MB	Yes

Appendix D

GIS Comparison

		ArcView	ADE	EIS	IMAGINE	MGE
Background	Version	2	1	Win 1.1	8.1	
	Yr first installed	1994	1993	1984	1992	1987
	Number of installations			3,000	3,800	120,000
	Estimated users			1,000	10,000	180,000
Software Type	GIS	YES			YES	YES
	Facilities mgt		YES			YES
	Automated mapping		YES			YES
	Digitizing					YES
	Format conversion					YES
	CAD		YES			YES
	Doc mgt					YES
	Desktop mapping	YES				YES
	Image processing				YES	YES
	DBMS					YES
	Document processing					YES
	Remote sensing					YES
	GPS	YES				YES
	Other			YES		
Operating System	UNIX	YES	YES		YES	YES
	DOS	YES	YES	YES		YES
	Mac	YES				
	Windows NT	YES			YES	YES
	OS/2					
	Other					
Data Structure	Raster	YES		YES	YES	YES
	3-D		YES		YES	YES
	TIN		YES		YES	YES
	Vector/Line		YES	YES	YES	YES
	Other	YES	YES			YES

		ArcView	ADE	EIS	IMAGINE	MGE
Geographic Coordinates						
Coordinate Systems Supported	Geographic (lat/long)	YES	YES	YES	YES	YES
	State plane	YES	YES	YES	YES	YES
	UTM	YES	YES	YES	YES	YES
	User-defined	YES	YES	YES	YES	YES
	Other				YES	YES
	Convert coord systems		YES		YES	YES
	Map projections spted	YES	YES	YES	YES	YES
	Convert map projections		YES		YES	YES
Data Entry/Input Devices	Manual digitizing		YES	YES	YES	YES
	Scanners		YES	YES	YES	YES
	GPS	YES	YES		YES	YES
	Photogrammetric				YES	YES
	Mouse		YES	YES	YES	YES
	COGO Spt		YES			YES
Raster/Vector Integration	Convert raster to vector				YES	YES
	Convert vector to raster			YES	YES	YES
	Register vector over raster		YES	YES	YES	YES
Spatial Data Exchange Formats	ARC	i,e		i	i,e	
	AVHRR				i	i,e
i—import	USGS DEM				i,e	i,e
e—export	CGM	i,e				i,e
	DIGEST					i,e
	DLG			i	i,e	i,e
	DTED				i	i,e
	DXF		i,e	i	i,e	i,e
	EDIGEO					i,e
	ERDAS	i			i,e	i,e
	ETAK			i	i	i
	GIRAS					
	HPGL					i,e
	IGDS					i,e
	IGES				i,e	i,e
	ISIF					i,e

		ArcView	ADE	EIS	IMAGINE	MGE
	LANDSAT	i			i,e	i,e
	MOSS					i
	NTF				i,e	
	SDTS					i,e
	SIF				i,e	i,e
	SPOT	i			i,e	i,e
	TIGER			i	i,e	i,e
	ASCII	i	i,e	i,e	i,e	i,e
	VPF					i,e
	Other	YES				
Data Management	Internal database		YES	YES		
	DB2	YES				YES
	dBASE	YES	YES			YES
	DS					
	Foxbase	YES				YES
	Object-oriented					YES
	IMS					YES
	INFO	YES				YES
	Informix	YES	YES			YES
	Ingres	YES				YES
	Oracle	YES	YES			YES
	OS/2 E.E. Database mgr					
	Rbase					
	Sybase	YES				YES
	Other	YES		YES		
Data Analysis						
Measurement	Straightline distance	YES	YES	YES		YES
	Distance along an arc	YES	YES			YES
	Area	YES	YES			YES
	Frequencies	YES	YES			YES
Retrieval	By cursor input	YES	YES		YES	YES
	By keyboard input	YES	YES	YES	YES	YES
	Selection by attribute query	YES	YES	YES	YES	YES
Generate Buffers	Around points		YES		YES	YES
	Around arcs		YES		YES	YES
	Around areas/polygons		YES		YES	YES
	Weighted				YES	YES
Map Analysis Functions	Recode or reclassify	YES	YES		YES	YES
	Overlays multiple layers	YES	YES	YES		YES

		ArcView	ADE	EIS	IMAGINE	MGE
	Average cell values				YES	YES
	Min./max. cell value				YES	YES
	Logical combination		YES		YES	YES
	Add/subtract maps		YES		YES	YES
	Multiply/divide maps		YES		YES	YES
Local Operator	Clump				YES	YES
	Shape characteristics					YES
Surface Analysis	Slope angle				YES	YES
	Interpolate elevation at any pt				YES	YES
	Generate line-of-site at any pt				YES	YES
	Generate line-of-site for arcs/areas				YES	YES
	Generate contours				YES	YES
	User-defined breaklines					YES
	Calculate optimal path					YES
	Generate cross sections					YES
Network Operations	Cut and fill calculations					YES
	Shortest path along network					YES
	Accum. network attribute values					YES
	Route allocation	YES				YES
	Spatial adjacency search					YES
	Nearest neighbor search	YES				YES
	Address matching	YES				YES
Polygon Operations	Dynamic segmentation	YES				YES
	Polygon overlays	YES	YES		YES	YES
	Point to polygon	YES	YES			YES
	Line in polygon				YES	YES
Digital Image Analysis						
Preprocessing	Merge/dissolve by attribute				YES	YES
	Digital orthophoto				YES	YES
	Radiometric corrections				YES	YES
	Sensor corrections			YES	YES	YES
	Merge data sets				YES	YES
Enhancement	Geometric corrections				YES	YES
	Filtering			YES	YES	YES
	User definable filters					
	Contrast Stretch				YES	YES

		ArcView	ADE	EIS	IMAGINE	MGE
	Color domain conversions				YES	YES
	Density slicing				YES	YES
	Histogram				YES	YES
	Histogram equalization				YES	YES
Extraction	Mosaicking				YES	YES
	Principal components analysis				YES	YES
	Band ratios				YES	YES
	Supervised classification				YES	YES
Miscellaneous	Unsupervised classification					YES
	Thiessen/Voronoi . . .					YES
	Catchment basins				YES	YES
	Cross-tabulation reports	YES			YES	YES
	Export summary statistics	YES				YES
	Integrated metadata support				YES	YES
	Generate random samples				YES	YES
	proximity analysis				YES	YES
Editing						
	Weighted proximity analysis				YES	YES
	Topological vector digitizing			YES	YES	YES
Vector Editing Tools	Raster digitizing	YES	YES		YES	YES
	Line generation		YES			YES
	Edgematch		YES			YES
	Topological error check					YES
	Attribute range check		YES			YES
	Overshoots/under check		YES		YES	YES
User interface						
	Snap to node		YES			YES
	Uses command language	YES	YES	YES	YES	YES
Windows environment	Menus (lists, pop-up, pull-down)	YES	YES	YES		YES
	Windows 3.1	YES				
	Mac					
	Presentation Manager	YES				
	Motif	YES			YES	YES
	X windows	YES				YES
	Other	YES	YES	YES	YES	YES
	Multiuser capability	YES	YES	YES	YES	YES
	User-customizable menus	YES	YES	YES	YES	YES
	User generated macros	YES	YES	YES	YES	YES
	Online help	YES	YES		YES	YES

		ArcView	ADE	EIS	IMAGINE	MGE
Data Displays						
	Context sensitive	YES	YES		YES	YES
	Multiple maps on single plot		YES		YES	YES
	Shaded relief		YES		YES	YES
	Wireframe		YES		YES	YES
	Thematic layer drape		YES		YES	YES
	User-defined grids	YES	YES	YES	YES	YES
Annotation Text	Cartographic elements	YES	YES	YES		YES
	Change font size	YES	YES			YES
	Set angle	YES	YES			YES
	Align along feature					YES
	Animation	YES		YES		YES
Output Device	Multimedia	YES	YES			YES
	Pen plotter	YES	YES		YES	YES
	Electrostatic plotter	YES	YES	YES	YES	YES
	Laser printer	YES	YES	YES		YES
	Ink jet printer		YES			YES
	Film recorder	YES	YES	YES		YES
	Dot matrix printer				YES	YES
Graphic Output Formats	Other		YES		YES	YES
	Print to disk capability	YES	YES		YES	YES
	PS	YES	YES		YES	
	EPs	YES				YES
	PICT		YES			YES
	HPGL	YES	YES	YES	YES	YES
	TIFF					YES
	PGL	YES		YES		

Glossary

AAFIF	Automated Air Facilities Information File
ABO	Air Base Operability
ACEPES	Automated Civil Engineer Planning and Execution System
ACES	Automated Civil Engineer System
ACC	Air Combat Command
ADRG	Arc Digitized Raster Graphics
AF	Air Force
AFCE	Air Force Civil Engineer
AFCESA	Air Force Civil Engineer Support Agency
AFI	Air Force Instruction
AAFIF	Automated Airfield Facilities Information File
AFLMA	Air Force Logistics Management Agency
AFM	Air Force Manual
AFPAM	Air Force Pamphlet
AIS	Automated Information Systems
AMC	Air Mobility Command
AM/FM	Automated Mapping/Facilities Management
ASG	Automation Steering Group
AutoACE	Automated Airbase Contingency Estimator
AUTODIN	Automated Data Information Network
BCAT	Beddown Capability Assessment Tool
BCE	Base Civil Engineer
BCP	Base Comprehensive Plan
BDA	Battle Damage Assessment
BSP	Base Support Plans
CADD	Computer Aided Design and Drafting
CE	Civil Engineer
CCD	Camouflage, Concealment, and Deception
CONPLANS	Concept Plans
COTS	Commercial-Off-The-Shelf
CRISIS	Combat Readiness Infrastructure Support Information System
C2	Command and Control
C4I	Command, Control, Communications, Computers, & Intelligence
DAFIF	Digital Aeronautical Flight Information File
DARPA	Defense Advanced Research Projects Agency
DAT	Damage Assessment Team
DBMS	Database Management System

DCC	Damage Control Center
DCW	Digital Chart of the World
DISA	Defense Information Services Agency
DISE	Deployment Information and Simulation Environment
DMA	Defense Mapping Agency
DOD	Department Of Defense
EIS	Emergency Information System
EOD	Explosive Ordnance Disposal
ESRI	Environmental Systems Research Institute
ECLiPSE	Enhanced Contingency Logistics Planning Support Environment
FM	Facility Management
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GIS	Geographic Information System
GOTS	Government-Off-The-Shelf
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
IPT	Integrated Process Team
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JLEB	Joint Logistics Electronic Battlebook
JMTK	Joint Mapping Tool Kit
LAN	Local Area Network
MAJCOM	Major Command
MCG&I	Mapping, Charting, Geodesy & Imagery
METT-T	Mission, Enemy, Terrain, Troops—Time
MGE	MicroStation Graphics Engine
MOOTW	Military Operations Other Than War
MOS	Minimum Operating Strip
NAVAIDS	Navigational Aids
NIMA	National Imagery and Mapping Agency
O&M	Operations & Maintenance
OPLAN	Operational Plan
PACAF	Pacific Air Forces
POL	Petroleum, Oil, & Lubricants
Prime BEEF	Base Engineer Emergency Force
RAM	Random Access Memory
REACT	Rapid Emergency Assessment and Contingency Toolkit
ROM	Read Only Memory
RRR	Rapid Runway Repair
SAIC	Science Application International Corporation
SORTS	Status Of Resources and Training System
SIPRNet	Secret Protocol Router Network
SVGA	Super Video Graphics Array
TBM	Theater Battle Management

TCMS	Theater Construction Management Systems
TEC	U.S. Army Topographic Engineering Center
TPFDD	Time Phased Force Deployment Data
TPFDL	Time Phased Force Deployment List
TSSDS	Tri-Service Spatial Data Standards
WCCS	Wing Command and Control System
WIMS	Work Information Management System
WMCCS	Worldwide Military Command and Control System
U.S.	United States
USACOM	United States Atlantic Command
USAF	United States Air Force

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